PHD

Safety Culture, safety climate and risk decision making in UK military naval aviation

Ashford, Anthea

Award date:
2020

Awarding institution:
University of Bath

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A thesis submitted for the degree Doctor of Philosophy

University of Bath

Department of Psychology

November 2018

DECLARATION OF ANY PREVIOUS SUBMISSION OF THE WORK

The material presented here for examination for the award of a higher degree by research has not been incorporated into a submission for another degree.

AAshford.

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Acknowledgements

While completion of a Doctoral thesis can be a somewhat solitary journey, there have been a number of important people who have joined me at various stages to support, encourage and advise me. Firstly, Dr Andrew Weyman (Reader, Department of Psychology, University of Bath), my primary supervisor who has provided not only invaluable advice and direction, but has also been the voice of reason on many an occasion. It has been a privilege to be guided and mentored by Dr Weyman.

Dr Elizabeth Hellier (Associate Professor, Psychology Department, University of Plymouth), as co-supervisor, has provided valuable advice and feedback throughout the research, giving generously of her time to support me in succeeding in this endeavour.

Thanks must go to my colleagues at the Institute of Naval Medicine who have enabled me to undertake my PhD while working, and to the Royal Navy who financially supported the PhD. I would like to acknowledge all of the individuals who took an interest and participated in my research studies - without them the thesis would not have been a reality.

Finally, thank you to the friends and family (both Bennetts and Ashfords), who have supported me through the highs and lows, read the thesis, and never tired of asking the question "How is the PhD going?". I know you will be grateful that life post-thesis can resume! Jon, you have always given me the time, space and support I needed to complete this thesis, so thank you for all you have done.

To my parents, Jim and Jane Bennett, who always believed that education was the most important thing that they could give their children, this is dedicated to you.

Anthea Ashford
University of Bath
November 2018

Abstract

The aims of the current thesis were, firstly, to explore and characterise the effects of safety culture and climate on decision making in the presence of risk within the Royal Navy's Fleet Air Arm (FAA). Secondly, from the perspective of organisational learning, the thesis aimed to provide insight into ways to enhance resilience to failure through exploring the scope for developing sector-specific, quantifiable leading indicators with the capacity to detect weaknesses in safety climate and identify priorities for improvement.

Purposively adopting a sequential mixed method approach, four empirical studies were undertaken. The first study adopted a qualitative approach, aiming to explore structural and socio-technical influences on workplace safety culture. Use of focus groups to generate data that was thematically analysed led to identification of seven salient themes: *policy & procedures*, *pressure*, *leadership & safety ownership*, *individual & collective responsibility*, *communication*, *training & experience* and *organisational commitment*. The second empirical study compared three alternative methods for eliciting employee perspectives on priorities for intervention to enhance the safety culture/climate of their workplace (Q-Sort, direct ranking and the method of paired comparisons). No significant differences in the ranking of priorities were detected. The method of paired comparisons afforded greater insight into the relative weighting of culture/climate elements, however the additional value of the interval scale produced needs to be balanced against associated respondent frustration relative to Q-Sort and direct ranking methods. *Human resources* (staffing levels)*, priority of safety* and *competency & experience* were identified as potential areas of concern amongst participants.

Study 3 aimed to elicit employee perspectives on safety climate in the FAA, using a self-complete survey. Exploratory factor analysis indicated the presence of six components. A confirmatory factor analysis in Study 4 refined this to five elements: *management & organisational learning, normative behaviour, training & experience, reporting* and *process & bureaucracy*. Study 4 further examined the scope for developing the climate components into a five-factor measure of FAA safety climate.

The research added to the body of military aviation research in relation to safety culture and climate, as well as to the body of mixed methods research within the safety culture / climate domain. Findings highlighted a number of implications for the FAA which were translated into practical recommendations for enhancing safety climate with the potential to improve safety culture, including: removal of barriers to compliance with procedures;

review of policy to consolidate in a central location and provide signposting; engaging users in development of procedures; examining the effects of a lack of *human resource* on safety and; enhancing coherence between formal and informal aspects of work.

List of Abbreviations

Advisory Committee on the Safety of Nuclear Installations	ACSNI
Air traffic control	ATC
Air traffic management	ATM
Analysis of variance	ANOVA
Australian Defence Force	ADF
Behavioural based safety	BBS
Centre for Environment and Risk Management	CERN
Closeness of fit	PCLOSE
Command Safety Assessment Survey	CSAS
Commercial Aviation Safety Survey	CASS
Comparative Fit Index	CFI
Computer assisted qualitative data analysis	CAQDAS
Confirmatory factor analysis	CFA
Crew resource management	CRM
Degrees of freedom	DF
Department for Environment, Food and Rural Affairs	DEFRA
Environmental Protection Agency	EPA
European Union	EU
Exploratory factor analysis	EFA
Fleet Air Arm	FAAFAA
Flight Management Attitudes Questionnaire	FMAQ
Goodness of Fit Index	GFI
Health and Safety	H&S
Health and Safety Executive	HSE
High Reliability Organisation	HRO
Institute of Naval Medicine	INM
International Nuclear Safety Advisory Group	INSAG
Interpretative Phenomenological Analysis	IPA
Maintenance Climate Assessment Survey	MCAS
Maintenance Resource Management/Technical Operations Questionnaire	MRM/TOQ
Military Aviation Authority	MAA
Ministry of Defence	MOD
Ministry of Defence Research Ethics Committee	MODREC
Model of Organisational Safety Effectiveness	MOSE

National Aeronautics and Space Administration	NASA
Normed Fit Index	NFI
North Atlantic Treaty Organisation	NATO
Organisational Safety Culture	OSC
Partial confirmatory factor analysis	PCFA
Patient safety culture in healthcare organisation	PSYCHO
Personal protective equipment	PPE
Petty Officer	PO
Principle components analysis	PCA
Risk Ranking Method	RRM
Root mean square error of approximation	RMSEA
Root Mean Square Residual	RMR
Royal Air Force	RAF
Royal Marines	RM
Royal Navy	RN
Safety Management System	SMS
Standard Operating Procedures	SOP
Suitably Qualified and Experienced Personnel	SQEP
Task-Load index	TLX
Tucker-Lewis Index	TLI
United Kingdom	UK
United States	US

Chapter 1: Introduction

1.0 Introduction

This chapter provides an introduction to the thesis, firstly with an overview of high-profile organisational accidents and incidents instrumental in shaping contemporary interest in, and perspectives on, workplace safety culture and climate. This is followed by an outline of the context in which the research reported in this thesis was situated through a description of changes to the regulation of safety in the United Kingdom (UK) Defence aviation environment, which prompted the Royal Navy's (RN) interest in supporting the research. This is supplemented by a description of the military naval aviation environment and research challenges, culminating in an overview of the thesis.

1.1 Organisational Accidents

In many respects the history of risk regulation and structural changes within the major hazard sectors reflects institutional responses to major events. Examples include chemical processing (Flixborough disaster of 1974, Parker, Pope, Davidson & Simpson, 1975), on-shore oil processing (BP's Texas City refinery explosion of 2005, Baker et al., 2007), offshore oil and gas (Piper Alpha disaster of 1988, Cullen, 1990), and the UK railway industry (Ladbroke Grove train crash of 1999, Cullen, 2001a, 2001b) each of which led to significant changes in the ways safety and risk were managed within the respective sectors. A common feature of investigations into these incidents was the identification of deficiencies in many of the layers of defence put in place to guard against accidents (Baker et al., 2007). How these defences interact with the cultural and psychological factors which influence employee safety behaviour has been suggested as key organisational learning with respect to understanding causality and the scope for future resilience (Taylor, van Wijk, May & Carhart, 2015). This interaction is often broadly referred to as the 'safety culture' of the organisation.

1.2 The Nimrod Review and the Defence Air Environment

For the UK military aviation sector, the key stimulus for significant structural and regulatory change was the crash of the Nimrod MR2 Aircraft XV230 in Afghanistan in 2006. The resultant two-year review led by Charles Haddon-Cave QC culminated in a wide-ranging report (The Nimrod Review, Ministry of Defence, 2009) which highlighted a range of organisational failings which were concluded to have contributed to the disaster. These were described in the Nimrod Review as shortcomings in the airworthiness system in the Ministry of Defence (MOD), and included:

a. *"A failure to adhere to basic Principles* [of airworthiness];

b. A Military Airworthiness System that is not fit for purpose;

c. A Safety Case regime which is ineffectual and wasteful;

d. An inadequate appreciation of the needs of the Aged Aircraft;

e. A serious weakness in the area of Personnel;

f. An unsatisfactory relationship between the MOD and industry;

g. An unacceptable Procurement process leading to serial delays and cost-overruns; and

h. A Safety Culture that has allowed 'business' to eclipse Airworthiness"

(Ministry of Defence, 2009 p 13).

Point (h) echoed findings from other major accident reports (Baker et al., 2007; Cullen, 1990) which cited deficiencies in organisational safety culture. When used in the context of organisational accident reports, this introduction of poor 'safety culture' as a contributory factor has often been attributed to the report produced after the Chernobyl disaster of 1986 (INSAG, 1991).

The Nimrod Review (Ministry of Defence, 2009) advocated the development of a 'new' safety culture for UK Defence aviation, with definition of a vision for this ‘new’ safety culture falling to the newly created Military Aviation Authority (MAA). This organisation was set up to regulate all aspects of aviation across the three Armed Services (the Royal Air Force (RAF), RN and British Army), broadly known as Defence Aviation organisations. The RN's aviation branch is known as the Fleet Air Arm (FAA).

The MAA proposed that safety culture was an important factor in supporting the Air Safety Management System which each Defence Aviation organisation was regulated to have. The MAA therefore proposed a model of Engaged Air Safety Culture that is reproduced in Figure 1, based on a model widely attributed to James Reason (1997), a detailed description of which is provided in Section 2.4.6 of Chapter 2.

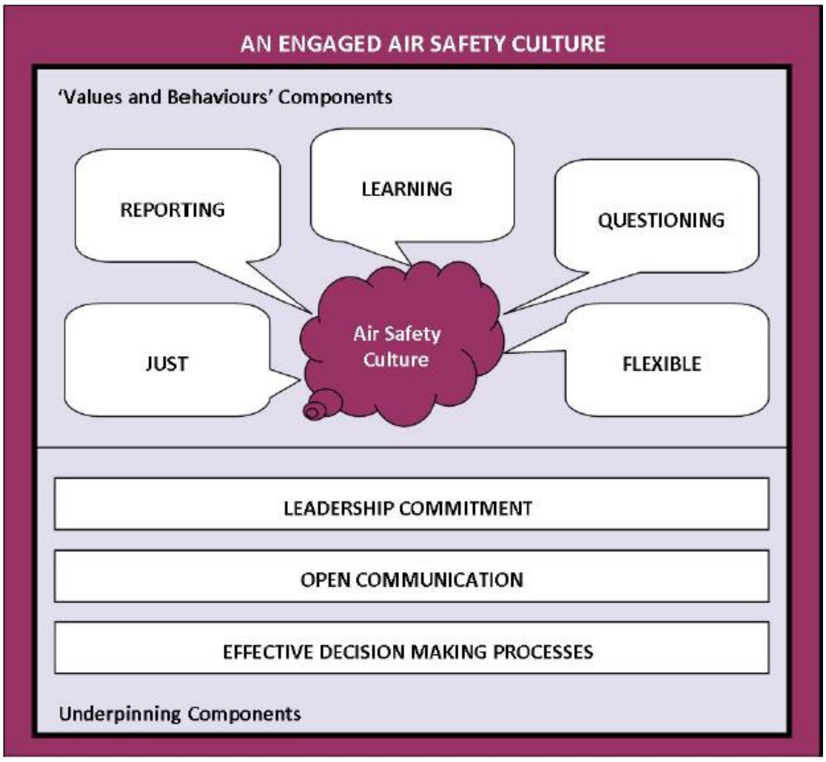

Figure 1. Components of an Engaged Air Safety Culture (taken from the Manual of Air Safety, Military Aviation Authority, 2014a p 29).

The MAA define an Engaged Air Safety Culture as

> *"that set of enduring values and attitudes, regarding Air Safety issues, shared by every member, at every level, of an organisation. It refers to the extent to which each individual and each group of the organisation: seeks to be aware of the risks induced by its activities; is continually behaving so as to preserve and enhance safety; is willing and able to adapt when facing safety issues; is willing to communicate safety issues; and continually evaluates safety related behaviour"* (Manual of Air Safety, Military Aviation Authority, 2014a p 29).

1.3 The Context of Military Aviation

While civilian and military aviation sectors may share similarities regarding engineering and technical perspectives, there are several key differences between them which may have an influence on how safety and risk are conceptualised; these include both structural and socio-cultural differences.

It is perhaps each sector's view on risk that most distinctly separates them. Haddon-Cave stated that *"A military organisation must be risk sensible but not too risk averse"* (Ministry of Defence, 2009, pg 499) as it is required to deliver a certain military capability, and balance the safety of operators and the system with hazards that are often extreme and unpredictable (Falconer, 2006a). For example, under operational conditions, personnel may need to consider risk to personal safety in the context of more fundamental threats to achievement of the operational mission (Börjesson, Lajksjö & Enander, 2007). Whilst this imperative is perhaps less applicable to non-operational situations, the requirement remains for military personnel to be willing and able to take calculated risks when required in pursuit of activities that are seen to support the wider organisational goal (Borjesson, Osterberg & Enander, 2011; Page, 1987). Indeed, a positive attitude toward safety and willingness to take risk are both compatible and desirable in military personnel (Borjession Osterberg & Enander, 2011). It might be argued that this is similar to productivity-safety trade-offs but is perhaps of a more fundamental and immediate nature. In most industries, the higher the level of safety exhibited by organisational members, the higher the level of safety for others. However, this might not hold true for the military as it reportedly does not for the fire service (Pessemier & England, 2012).

Risk is an integral part of military working life; while personnel may not be trained *per se* to take risks, it is expected that they understand and balance the risk with the potential benefit, and make a sensible decision (Page, 1987). Personnel in the UK Armed Forces are selected and trained to take calculated risks while simultaneously reconciling this with legislative and regulatory requirements to reduce risk to as low as is reasonably practicable (ALARP). The military approach to risk management, where higher risks are often determined to be tolerable if the possible operational gain is high (Liwang, Ericson & Bang, 2014), has also been suggested to differ from the civilian approach (in which risk is often not determined to be tolerable to any degree).

The nature of tasks and the working environment are also suggested to differentiate civilian and military aviation sectors. Military personnel often operate in challenging environmental conditions, which reduces the ability to control for risks in the physical environment, thus increasing the importance of safe behaviour (Luria, 2010). The complexity of military aviation missions implies high risk activity (Iordache & Balan, 2016), making safety behaviour of personnel of prime importance. The exceptional nature of the military maritime operating environment often places resource and temporal limitations on personnel working in these situations (Luria, 2010; Saward & Stanton, 2015).

A further difference between the nature of tasks undertaken in military and civilian sectors is the dominant aircraft type in each, and the ways in which these are utilised. While commercial civilian sectors tend to utilise predominately fixed wing aircraft (for commercial air travel), the military is often characterised by rotary wing aircraft (helicopters) which are considered more agile. Commercial aircraft are typically used for transportation of passengers and cargo, whilst military aircraft are utilised for a far wider range and variety of activities (including search and rescue, tactical operations and combat).

The demographic profile of military organisations exhibits contrasts when compared to civilian organisations. The RN is typically comprised of approximately 90% male personnel, most of whom are relatively young, 22% are between 18 and 24 years old, 43% between 25 and 34 years, and only 35% older than 35 years of age (Dempsey, 2017). This relatively young, predominately male workforce does not reflect the wider UK working population, but shows similarities with other high risk emergency services such as the fire service,[1] and police.[2]

Unlike most civilian aviation workers, UK military aviation personnel typically live and work together, for periods of approximately two years; in effect the military is a fully functioning community with doctors, drivers, cooks, and police amongst others. It has been suggested that this context strengthens the inculcation of the military culture (Redmond et al., 2015). Most military personnel, if not directly engaged in combat, will have careers focussed on supporting the overall military mission (Redmond et al., 2015). While the military's principle role is war, individuals are acknowledged to differ in the level to which they are involved in direct combat (Redmond et al., 2015); some may therefore be more directly involved in humanitarian missions, training and support roles.

Structurally, military organisations generally differ from those in the civilian sector in that their strict hierarchy, high reliance on regulations and cultures of control (rules, procedures, norms) have been suggested to be strong enough to influence subordinate behaviour to a degree which may not, generally, be reflected in civilian organisations (Martinez-Corcoles & Stephanou, 2017). Military personnel are bound by military laws and traditions that do not apply to civilians (Redmond et al., 2015), while the opposite is rare. Mechanisms/policies designed to encourage voluntary safety participation in civilian contexts are thought to be harder to introduce in a military setting (Martinez-Corcoles & Stephanou, 2017).

[1] 95% male, 62% under the age of 45

[2] In the UK Police, approximately 71% of personnel are male, 51% of Police Officers are between the ages of 18 and 39

The factors outlined above make the military context one in which the concepts of safety and risk might be viewed differently to the civilian context (Borjesson, Osterberg & Enander, 2015; Iordache & Balan, 2016). However, given the aviation focus of the FAA, it may also be expected that there would likely be some similarities with the civil aviation sector, and so research relating to this was included within the review of literature (Chapter 2).

1.3.1 Emergence of the Thesis

A review of the safety culture and safety climate literature (Chapter 2) revealed a number of interesting theoretical questions relating to how these concepts might be characterised in different contexts, and the degree to which differences between organisations/sectors might influence the dimensions of safety culture and climate. The variability in findings amongst studies conducted in various contexts might suggest that constructs are prone to vary between populations which exist in various regulatory, structural and socio-technical contexts (Jeffcott et al., 2006; Reiman & Rollenhangen, 2011). To date, there has been relatively little research into defining influences on safety culture/climate in military populations (O'Conner et al., 2011b).

Interest in the concepts of safety culture/climate within RN aviation pre-dated the Engaged Air Safety Culture model shown in Figure 1, however the research sponsors were of the opinion that the FAA had not as yet derived significant benefit from contemporary insights. This highlighted the requirement for further research to be conducted and formed the basis of the case for funding for this PhD studentship, with the remit of deriving a better and more complete understanding of the prevailing safety culture(s) and defining influences, underpinned by critical reflection upon the suitability and utility of methods currently employed by the FAA to understand and monitor safety culture.

The author is a civilian, based within the Human Factors Department at the Institute of Naval Medicine (INM). The INM is the RN's centre of excellence for occupational health advice information, training and research. The alignment between this thesis and the FAA's safety management objectives provided a research context with the potential real world application of findings, but brought with it challenges with respect to managing stakeholder expectations and interests and gathering empirical evidence. The following section provides an overview of the organisation in which the research was conducted, followed by a brief outline of some challenges and benefits of applied research as experienced during this research.

1.3.2 The Sponsor Organisation

The RN is comprised of five ‘arms’ which include the Surface Fleet, the Submarine Service, the Royal Marines, the civilian Royal Fleet Auxiliary and the aviation FAA. The focus of the current research was on the FAA. The FAA is responsible for the co-ordination and operation of naval aircraft, and is comprised of approximately 4620 personnel.[3] Operating predominately rotary wing aircraft (i.e. helicopters), the FAA undertakes a wide range of roles which include providing maritime security, surface and sub-surface warfare and surveillance roles, providing disaster relief and humanitarian assistance, as well as a wide range of training and specialist support and air displays across the UK. This wider range of roles means that FAA personnel can operate in a wide array of environments, from particularly challenging maritime or operational contexts through to more benign training environments.

Military Naval Aviation Population: The Research Focus

Roles within RN aviation typically fall within the categories of aircrew, engineering, air traffic control (ATC) and support roles. Aircrew are comprised of pilots and observers who fly the aircraft and perform navigational/system control roles; engineers are responsible for maintaining, servicing and inspecting the aircraft and weapons; ATC perform air traffic control roles, and support roles can vary widely from logistics (storekeepers, pay clerks, chefs, stewards) to aircraft handlers (who are responsible for the safety of the aircraft when on the ground). Most personnel within the FAA are employed within either the aircrew or engineering trades and these personnel are those who have most frequent physical interaction and contact with the aircraft. The research only focused on personnel who were involved in the operation of aircraft, and therefore this did not include people involved with aspects of either designing or procurement of aviation-related equipment.

As with most military organisations, a hierarchical rank structure is in place, with personnel typically being identified as either Officers or Other Ranks/Ratings. A full outline of the North Atlantic Treaty Organisation (NATO) rank structure across the UK armed forces is contained within Appendix A.

1.3.3 Applied Research: Challenges and Benefits

Given the theoretical question of how safety culture/climate concepts may be characterised in a military context, addressing this required undertaking research in an applied setting. This necessitated alignment between what was theoretically desirable

[3] In October 2017

(i.e. academic objectives) and what was practically possible (i.e. what constraints existed), and resulted in a number of both challenges and benefits.

Applied research is often characterised by dual aims; firstly, contributing to academic knowledge within the established body of research while, secondly, generating practical insight relevant to the organisation/sector in which the research is based. Examples of challenges faced in the current research included sampling and ethics, both of which are outlined below. For robustness, probability and purposive sampling are often preferred for quantitative and qualitative research respectively (Teddlie & Yu, 2007). However, much of the sampling within this thesis was convenience sampling, due to limitations on the availability of serving military personnel. However, if the research is underpinned by a sound understanding of philosophical assumptions and a well thought out design, challenges such as these do not need to compromise applied research (Jones, 2014).

Regarding ethics, research in military environments can be complicated by the tendency of military personnel to follow orders. Thus, it was very important to ensure that volunteers were properly informed, and were not coerced into participating. The author addressed this challenge through ensuring the research was ethically approved (either by the Ministry of Defence Research Ethics Committee (MODREC) and/or the University of Bath, as required) and that the research was conducted within the bounds of these ethical protocols. This also required significant education and briefing of military gate-keepers to (i) ensure that participant information was distributed freely prior to inviting volunteers to participate in the research and (ii) ensure that data collection was conducted away from the chain of command to minimise any pressure felt by potential participants to volunteer. The fact that the author was a civilian, and not a ranking officer or member of the RN, is likely to have assisted in this.

In the RN/FAA, personnel typically move job postings every two years, so maintaining continuity during a multi-stage research program was an important challenge to address. This was achieved through the author ensuring that details regarding the research program were contained within handovers and briefs between outgoing and incoming stakeholders. Access to personnel for data collection in applied settings such as this was also often a challenge. Data collection often had to be scheduled into operational programs, which themselves are fluid and subject to short notice changes. This required a degree of flexibility and responsiveness from the author to ensure that data collection targets could be achieved within the timeframe of the doctorate. The military setting also occasionally limited the type of information or documentation that could be reviewed or included within the thesis due to security classification restrictions.

Despite the challenges, there were a number of benefits associated with situating the research within an applied setting. Firstly, access to a military population afforded insight into the unique context in which military personnel operate (as described in Section 1.3), and how this might influence safety and risk decision making. Access to military personnel for the purposes of research is often limited, and as most of the established aviation safety culture research is sited within the civilian sector, insights into the military context had the potential to offer a different perspective to that already captured in the established literature. Furthermore, applied research enables the 'testing' of theoretical perspectives for face validity and relevance in a real life setting, thereby determining the ability of the abstract safety culture and climate concepts to achieve practical utility.

1.4 Overview of Empirical Chapters

This thesis has been structured around four empirical studies which were conducted to address the aims and objectives of the research. The respective aims of each, and how the studies link together, is as follows:

Study 1 (Chapter 4), Exploring and understanding employee attitudes to safety culture, behavioural norms and risk decision making in a military naval aviation organisation

The aim of this qualitative study was to gain a rich and detailed insight into FAA personnel perspectives on how prevailing safety climate, notably structural, socio-technical, and normative elements impacts on the values, attitudes and behaviour of operational personnel in relation to safety, particularly shared perspectives. The key contribution of this foundation study is held to be in its embeddedness within the accounts of personnel, to produce a data driven, methodologically bottom-up perspective. This insight informed decisions over the focus for more structured investigation in later stages of the research.

Study 2 (Chapter 5), Ranking priorities for safety improvement

To complement findings from Study 1, Study 2 set out to determine FAA personnel perspectives on priorities for enhancing safety culture / climate within their workplaces. The output from three widely applied ranking techniques was compared and produced closely aligned profiles. Each emphasised the primacy of *human resources* (staffing levels), *priority of safety* and *competency/experience* as headline issues that were identified as representing possible priorities for ameliorative intervention.

Study 3 (Chapter 6), Quantitative exploration of variables impacting on employee perceptions of safety climate in military naval aviation

Building on insights from Studies 1 and 2, Study 3 aimed to distil the constituent themes into a set of statements (referenced to a simple agree-disagree scale) to produce an employee safety climate survey. Study 3 aimed to triangulate findings from Study 1, in particular, to quantitatively examine relationships between identified variables, with a view to developing a finite set of components considered to characterise headline influences on safety climate.

Study 4 (Chapter 7), Toward the development of a safety climate tool for use in military naval aviation

The aim of the final study was to use confirmatory techniques to determine the validity of the model developed in Study 3, and to explore the scope for developing an employee survey-based safety climate assessment tool, with the capacity to profile and benchmark the status of precursor influences on safety behaviour.

Chapter 2: Literature Review

2.0 Introduction

This chapter outlined the evidence base relating to organisational safety culture and climate and how this applied to military aviation organisations. Given the notable overlap, both philosophically and methodologically, between organisational culture and climate research and safety culture and climate research, only a brief synopsis of the former was given, with an in-depth critique saved for the latter. Given the military aviation context, a specific focus of this review was on existing military research. However, the scarcity of studies meant that civilian research was also included. The evidence supporting or refuting a relationship between safety culture/climate and safety performance was critiqued and a short overview of safety, risk management and organisational learning, specific to the military context, concluded the chapter.

The purpose of the review of the literature was to determine what is known in this area, and identify knowledge gaps, the latter of which were used to inform thinking over the design and focus of the research reported here. Whilst research on organisational (safety) culture and (safety) climate has been of interest to anthropologists, political scientists and sociologists (Guldenmund, 2010a), this review is bounded to insights from applied psychology, organisational psychology and human factors domains. While other domains are acknowledged, they are considered to fall outside the scope of the review because they do not contribute to the overall aims of the current research.

2.1 Background

For many industries, a large scale/high consequence organisational accident is often the catalyst for a major industry-wide review of how safety is regulated and managed. Some of the most widely known and high profile of these include the UK railways (Ladbroke Grove rail crash, Cullen, 2000a, 2000b), both on-shore oil processing (BP's Texas city refinery explosion, Baker et al., 2007) and offshore oil extraction (Deepwater Horizon Rig explosion and fire, US Chemical Safety and Hazard Investigation Board report, 2010) and spaceflight (Challenger, 1986 & Columbia, 2003). For the UK military aviation sector, such a catalyst occurred in 2006 when the Nimrod MR2 Aircraft XV230 crashed in Afghanistan, resulting in fourteen fatalities (Ministry of Defence, 2009).

A common feature of these large scale incident reports is that deficiencies were identified as being present despite multiple layers of defence (Baker et al., 2007). Systematic analysis of how the boundaries between the various defences interact with the cultural and psychological factors which shape human behaviour have been identified as key to understanding and supporting safety and organisational learning (Taylor, van Wijk, May & Carhart, 2015). Increasingly, the typically complex web of interactions in accident reports tend to be referenced to the prevailing 'safety culture'. Indeed, many industries appear to implicitly accept that a positive safety culture is a key aspect of safety management without which safety interventions may be ineffective (Farrington-Darby et al., 2005).

The term, and to some degree the concept, of safety culture has achieved the status of having become embedded in the safety management discourse of the nuclear power production (Harvey et al., 2002; Rollenhagen et al., 2013), aviation (O'Conner et al., 2011b), oil and gas (Mearns et al., 2001), railway (Morgan et al., 2016), healthcare (Chesters et al., 2016; Nixon et al., 2015) and maritime sectors (Havold, 2005), amongst others. However, few accident investigation reports make a clear distinction between safety culture and its allied concept, safety climate, with the terms often being used interchangeably. Fewer still acknowledge linkages to the broader concepts of organisational culture and climate (Guldenmund, 2010a). Perhaps, because the field has been described as fragmented (Schneider et al., 2013), achieving consensus over the core concepts of either culture or climate has proved elusive.

2.2 Organisational Culture and Climate

The term organisational culture has been used to describe numerous concepts, from behaviours through to corporate values (Schein, 1984; 1990), and gained popularity in the 1980s when it was marketed to managers pursuing a competitive edge (Bellot, 2011). Interest in organisational culture attracted the attention of sociologists and organisational psychologists through the work of Andrew Pettigrew (1979), who focussed on the evolution of organisations and how these might 'create' a culture within themselves.

Although there is significant disagreement between scholars and disciplines as to how organisational culture may be defined or assessed (Bellot, 2011) most definitions incorporate reference to shared values and assumptions creating a collective identity which might help to explain why organisations *"do what they do and focus on what they focus on" (*Schneider, Gonzalez-Roma, Ostroff & West, 2017, p 468). Edgar Schein defined organisational culture as *"the perceptions, language and thought processes that a group comes to share...the ultimate causal determinant of feelings, attitudes, espoused values and overt behaviour"* (Schein, 1990 p 111). Many definitions also share the premise that organisational culture reflects a learned set of values that may take the form of practices interpreted through rules and norms of behaviour (Harvey et al., 2002). The focus on cognitive components referenced to organisational culture such as beliefs, values or perspectives has prevailed within organisational psychology (Sackmann, 1992).

Despite the popularity of the concept of organisational culture, organisational climate has the longer research tradition (Moran & Volkwein, 1992; Schein, 1990). Research in this area has, for the most part, adhered to the notion that organisational climate is the integration between peoples' perceptions of their experiences with organisational practices and procedures which become meaningful and shared (Schneider et al., 2017). Organisational climate has been described as 'functional' because it provides a frame of reference against which employees can model their behaviour (Schneider, 1975) through their observations of overarching priorities and acceptable behaviours. Cox and Flin (1998) likened climate and culture to mood and personality, with the former being transient and sensitive to external pressure and the latter reflecting the stability of systems, procedures and behaviours within the organisation.

Despite significant academic and practitioner interest over the years, there is limited consensus with respect to understanding the concept, appropriate methods, or value and validity of enquiry into organisational culture (Bellot, 2011; Chatman & O'Reilly, 2016; Jung et al., 2009; Schneider et al., 2017). This situation is thought to have, in part, arisen due to the influence of consultants having eclipsed empirical academic insight and constructive debate in this area (Bellot, 2011; Chatman & O'Reilly, 2016). This criticism resounds with the current state of safety culture research and was discussed in Section 2.3 in greater detail. In contrast, organisational climate appears to be more coherently defined within the established literature.

Despite the terms often being used interchangeably, the history of culture and climate research shows that, viewed simplistically, the concepts appear to have developed from different research paradigms. Organisational climate has typically been sited within the positivist paradigm in which *"causes probably determine effects or outcomes"* (Creswell, 2003, p7), generally using quantitative methods (Jung et al., 2009) and hinges upon the premise that functional reification can reduce climate to a set of potentially malleable causal components. In contrast, studies of culture tend to reflect the constructivist/interepretivist underpinnings where knowledge and consciousness are argued to be socially constructed (Cohen & Manion, 1994; Mertens, 2005). Thus, early insight into culture was almost wholly gained using qualitative methods (Jung et al., 2009), although a tendency to favour the use of 'culture' when referring to both qualitative and quantitative studies has increasingly been observed in the literature.

The rise of quantitative methods applied to studies of culture in organisational psychology in the 1980s and 1990s has further served to blur boundaries between the concepts of culture and climate (Chatman & O'Reilly, 2016; Jung et al., 2009). This era gave rise to a burgeoning number (> 70) of measurement instruments used for exploring organisational culture (Jung et al., 2009). Much of this appears to have been driven by the need from within organisations to diagnose and facilitate comparisons between groups to inform organisational strategies (Yauch & Steudel, 2003). This era led to what Denison (1996) referred to as the 'paradigm wars', where differences in epistemology, methodology and level of analysis were emphasised by both organisational culture and climate camps, and epistemology become a focus for academic debate.

As early as 1975, Schneider posited that a more strategic and focused view of climate (rather than culture) may be applicable, dependent on the purpose of the study. Rather than attempting to develop an omnibus measure of 'organisational climate' he suggested that assessing the concept in a specific situation may be more useful. Consequently, it was posited that multiple 'climates' could concurrently exist within a single organisation, examples of which include service climate (Walumbwa, Hartnell & Oke, 2010), ethics climate (Dickson, Smith, Grojean & Erhart, 2001) and safety climate (Zohar, 1980, 2010).

2.3 Safety Culture and Climate

2.3.1 Background

As with organisational culture and climate, some have used the terms safety culture and safety climate interchangeably (Cooper, 2000; Cox & Flin, 1998; Dejoy, Smith & Dyal, 2017; Health & Safety Executive, 2005), while others have explicitly separated them (Mearns & Flin, 1999). The organisational psychology literature has been criticised for the ambiguity with which the terms are used (Baram & Schoebel, 2007) and measures of safety culture (Diaz-Cabrera et al., 2007; Grabowski et al., 2010; Morrow et al., 2014, Varmazyar et al., 2016) often appear functionally equivalent with those of safety climate (van Nunen, Reniers & Ponnet, 2016).

The popularisation of safety 'culture' in favour of safety 'climate' (Hale, 2000) appears to have arisen from its use in investigations of high profile accidents. In many reports of these accidents, poor or deficient organisational safety culture was said to exist prior to the disasters, being identified *post hoc* as a contributory factor. Whilst accident reports have given a notable platform to safety culture, these views are those of the accident investigators and are not empirically based; accident reports have been criticised for using safety culture as a 'catch all' concept (Silbey, 2009). Rarely have these accident reports acknowledged or made reference to safety climate as a concept.

The rise in popularity of the term safety culture was thought to be related to an increasing awareness that social factors are likely to impact on how people behave. However, although intuitively appealing, the concept of safety culture also runs the risk of becoming so inclusive as to lose conceptual meaning (Moran & Volkwein, 1992) or be seen as a 'philosopher's stone' (Cox & Cox, 1991; Flin & Cox, 1998) with which organisations can cure all their safety problems. Reiman and Rollenhagen (2011) recommended caution in taking the view that there is an 'ideal' safety culture to which all organisations should aspire, as this has yet to be empirically demonstrated, however intuitively appealing it may be. To determine the evidence for considering the utility of the terms safety culture and climate, a summary of the research in the areas of both areas to date is presented in the following sections.

2.3.2 Safety Culture

Common usage of the term safety culture is widely cited as having arisen in the nuclear domain, after the disastrous events occurring at the Chernobyl nuclear power plant in the (then) United Soviet Socialist Republic in 1986 (Choudrey et al., 2007; Cooper, 2000; Cox & Flin, 1998; Gherardi, Nicolini & Odella, 1998; Glendon & Stanton, 2000; Pidgeon, 1998). One of the earliest definitions of safety culture was drafted by the International Nuclear Safety Advisory Group (INSAG, 1991, p1); "*Safety culture is that assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, nuclear plant safety issues receive the attention warranted by their significance"*. This statement was comprised of both structural and attitudinal components, and contained organisational and individual connotations, all of which have endured through many of the later definitions of safety culture.

Subsequent research in other major hazard industries such as oil/gas and aviation gave rise to further definitions of safety culture. Shared beliefs and attitudes (Cox & Cox, 1991) as well as shared perceptions (Cooper & Phillips, 1994) were included within many definitions, while others have included the presence of underlying assumptions (Edwards et al., 2013), and their associated practices which underpin beliefs about danger and safety (Pidgeon & O'Leary, 2000). The addition of practices (Silbey, 2009) and safety behaviour (Lee, 1996) to safety culture definitions reveals the assumption that this concept can be observed in employee's patterns of behaviour and thus can become tangible and observable (INSAG, 1991). However, Silbey (2009) cautioned that definitions which include behavioural emphases might be erroneously used by management to focus the attention on frontline workers. Silbey (2009) argued that this focus may be misplaced given the relative lack of authority and influence over process safety issues that frontline staff have; rather this is potentially self-serving on the part of management.

The influence of process safety issues were acknowledged in some definitions of safety culture which referred to the influence of the work organisation, policy and practices on perceptions (Cabrera et al., 1997; Niskanen, 1994; Ostrom et al., 1993) and highlighted the importance of the organisationally driven context in which employees developed safety attitudes and in which safety behaviours were promoted (Grabowski et al., 2010). These definitions might be categorised as relating to normative beliefs as they focus on how people think and behave in relation to safety and risk (Cooper, 2000), but also reflect interpretive aspects in relation to how these beliefs are reciprocally created by group members (Hale, 2000).

The variety of foci within definitions of safety culture has given rise to confusion surrounding what safety culture encompasses, and what it does not. Some definitions are so broad that they become almost universal; for example, where *"safety is regarded by everyone as being an issue that concerns everyone" (*Choudrey et al., 2007, p 1003) or "*the way we do things around here*". When considering the breadth of safety culture definitions, Guldenmund (2000) and Weigmann et al. (2004) identified some common areas, including the view that culture was an abstract concept, was stable, was shared by groups and was multi-dimensional. Weigmann et al. (2004) added that safety culture is affected by, and affects, both employee behaviour and the formal safety structure, is manifested in employee practices in the workplace and is often reflected in the relationship between reward systems (either formal or informal) and safety performance, as well as the organisation's willingness to learn from adverse events. Although numerous definitions of safety culture have attempted to link culture to tangible variables, Lee and Harrison (2000) posit that the intangibility of the concept might in fact negate attempts to capture it in a definition.

2.3.3 Safety Climate

Safety climate has been defined by various authors as "*a summary of molar perceptions that employees share about their work environment*" (Zohar, 1980 p96), the "*perceived quality of an organisation's internal environment*', (Glendon & Stanton, 2000 p198), and the shared perceptions of policies and practices related to workplace safety (Neal & Griffin, 2006). Others have defined the term more loosely as a 'snapshot' of the state of safety (Flin et al., 2000) or the visible manifestations of the culture of the organisation (O'Conner et al., 2011b). Weigmann et al. (2004) suggested that the definitions of safety climate found in the literature have achieved some degree of commonality, namely that safety climate was:

i. A psychological phenomenon relating to perceptions of the state of safety at a point in time,
ii. Reciprocally affected by situational and environmental factors,
iii. A more unstable and temporary phenomenon than culture.

Safety climate has evidenced a longer research tradition than has safety culture; Dov Zohar conducted seminal quantitative work in the 1980's into safety climate on which much of the modern safety climate/culture literature is based. Zohar (1980) suggested that the importance of the concept of safety climate lay in the fact that it served as a frame of reference for guiding safety behaviour, being shaped in turn by cues in the work environment.

2.3.4 Summary: Integration of Safety Culture and Climate

The paradigm wars described in Section 2.2 (Denison, 1996) have had long lasting effects on how organisational culture and climate have been conceptualised. However, the more contemporary view is that the differences between culture and climate are in interpretation, rather than phenomenon (Denison, 1996). Indeed, the proposition has been made that the differences might be more apparent than real and that integration of the concepts might best serve the study of organisational contexts (Askanasy, Wilderom & Peterson, 2000; Denison, 1996; Schein, 2010; Schenider et al., 2017). Advocates of this integrated view have described culture as that which underpins climate (Williamson et al., 1997), with climate being the surface manifestation of the underlying culture (Guldenmund, 2000; Lofquist et al., 2011; Schein, 2010). Olive, O'Conner and Mannan (2006) referred to safety climate as the structural/socio-technical context on which culture persists, and culture as a stable and abstract concept. It follows, then, that climate has been suggested to be easier to influence in terms of safety improvement strategies (Nielson, 2014).

Both the safety culture and climate concepts have been described as multi-layered and multi-dimensional (Pettigrew, 1990; Reichers & Schneider, 1990), and both deal with the ways in which employees make sense of the organisational environment (Reichers & Schneider, 1990). Furthermore, both have been used to understand psychological phenomena and behaviour within organisations (Chatman & O'Reilly, 2016), notably socialisation processes, team processes and leadership. The effects of these are widely viewed as central to shaping both climate and culture (Schneider et al., 2017). From this integrated perspective, culture is a more global and encompassing concept than climate

(Denison, 1996; Jung et al., 2009), with culture conceptualised at the organisational level and climate at the individual or group level (Harvey et al., 2002).

Based on the evidence presented above, the conceptualisation of safety culture and climate as two interpretations of the same phenomenon (in line with Guldenmund, 2010a; Schnieder et al., 2017) was adopted in this thesis. Culture was conceptualised as a deeper, harder to access facet, while climate was considered to be that which was more easily observable and amenable to quantitative measurement. While this interpretation was utilised throughout this thesis in the empirical and discussion chapters, this is not the view of all researchers cited therein. Therefore, where literature was cited, the authors' original use of the terms safety culture/climate was maintained; where these diverged from the interpretation used in this thesis, this was highlighted.

Although there is a large body of safety culture and climate literature, the theoretical development of the field remains poor (Guldenmund, 2000; Kim & Wang, 2009). Much of the research has attempted to identify the various dimensions of safety climate (which are described in Section 2.5), however no stable model showing the relationships of these dimensions exists (Pidgeon & O'Leary, 2000). To explore this further, the following section outlined some of the existing theoretical models of safety culture.

2.4 Models of Safety Culture

2.4.1 'Levels of Culture'

Edgar Schein's multi-level conceptualisation of organisational culture (Schein, 1990; 2010) provided the basis for many later models of safety culture (e.g. Glendon & Stanton’s & Guldenmund's models) and so merits mention here. Schein's model (1990, 2010) contained three layers, each of which differed according to (i) how easily they could be observed and deciphered (ii) what they might say about the organisation and (iii) how they might be observed or measured. The first of these levels was that of artefacts; easily observable within the organisation, these were said to have included physical layout, dress code, formal management structure, as well as documentary evidence such as mission statements. Schein (2010) sited organisational climate at the level of artefacts and suggested that the best way to interpret these artefacts was for the researcher to live and work amongst the group for some time, during which the meaning of the artefacts might become clear. In the absence of this he suggested that speaking to employees and considering the day-to-day operating procedures which guide their behaviour might provide insight and access to the second layer, espoused beliefs and values.

Espoused beliefs and values, characterised as relating to what the organisations 'says' it does, was said to be potentially accessed through a combination of interviews, questionnaires and observations (Schein, 2010). Akin to the innermost core of an onion, Schein's final layer was that of underlying assumptions, the most difficult to access. These, he proposed, were the unconscious processes which underpinned perceptions and attitudes, and therefore may reflect the culture. Schein further described the underlying assumptions as being taken for granted, thus not being immediately apparent to insiders (Schein, 2010). Johnson (1992) suggested that these underlying assumptions were likely to evolve over time, potentially being more obvious to outsiders than those within the organisation.

Guldenmund's 'Levels of Culture'

Guldenmund (2000) adapted Schein's layered model in relation to safety culture and described the outer layer (Schein's artefacts) as being characterised by posters, personal protective equipment (PPE), accidents or near misses and safety behaviour. The middle layer (espoused values/norms) were suggested to manifest as the employee attitudes toward the artefacts such as hardware (e.g. PPE), software (e.g. procedures, training), people (e.g. management, supervisors, colleagues) and behaviour (e.g. responsibility, safe working). These therefore were said to be determined through studying policies, training manuals, accident reports, safety minutes and employee attitudes. The innermost layer of basic assumptions, Guldenmund (2000) suggested, could only be deduced from the outer two layers, accompanied by observation (Guldenmund, 2000).

Cooper (2000) reviewed these layered models of culture and suggested that it was sensible to assume that the underlying assumptions of an organisation were reflected in policies, structure and control mechanisms and styles of management, and that examination of these might provide insight into culture. However, as culture was said to be reflected in the innermost basic assumptions i.e. those which are difficult to decipher, when utilising this layered model of culture, Cooper (2000) argued that researchers could not hope to 'measure' culture. Criticisms of the layered model of safety culture have included its simplistic assumption of a linear relationship between the three layers and the lack of instruction about how these might affect safety behaviour (Cooper, 2000).

Glendon and Stanton's 'Levels of Culture' Conceptual Model

Glendon and Stanton (2000) also utilised Schein's layered model as a basis for their conceptual model of safety culture and climate, but added an extra axis of time, reflecting these author's view that culture is created in the past while climate is measured in the present. These additions were held to highlight the need to consider the extent to which culture is shared between organisational members (breadth axis) and the fact that culture can change over time (past-future axis). Glendon and Stanton (2000) used this conceptual model to suggest that climate was a measure/indicator of current (or very recent past) culture, but, when administered repeatedly over time, might more strongly and accurately represent the underlying culture.

2.4.2 INSAG's Safety Culture Model

In their report on safety culture, INSAG (1991) outlined a conceptualisation of what they suggested to be the major components of safety culture. At the highest level, safety culture was separated into two general components:

i. The framework within the organisation which reflected the responsibility of the management hierarchy (called *Management's commitment*) and
ii. The attitude of staff at all levels in relation to this framework (called *Individuals' commitment*).

While these higher-level phenomena were acknowledged to be intangible (INSAG, 1991), each was sub-divided into a number of areas which themselves represented tangible manifestations. These included, for example; qualifications, training, audits, attitudes and communication. These could, therefore, be observed through consideration of the environment created by local management, the attitudes of employees and the actual safety experience within the organisation (Sorensen, 2002). INSAG (1991) listed 143 questions, or 'safety culture indicators' to encourage self-examination in organisations. These questions encompassed the sub-divisions of their proposed model, but were more posed to encourage reflection and discussion around pertinent safety points, than providing a measure of safety culture *per se*.

This list of indicators was extensive and embracing, and has been criticised for giving no guidance on overall criteria for acceptability nor providing a mechanism to assess culture (Sorensen, 2002). However, this was never a stated aim of INSAG (1991), rather this model was intended to provide nuclear installations with a starting point from which to reflect on their own safety. The relationship between these indicators and improved human performance, as well as organisational safety performance, was at this point assumed by INSAG. However more recent research has sought to clarify these relationships (see Section 2.7 for an outline of empirical investigations into the relationship between safety culture/climate and outcome measures), with some degree of success.

2.4.3 Cooper's Reciprocal Determinism Model

Cooper (2000) proposed his reciprocal determinism model which was based on prior work on goal setting theory (Locke & Latham, 1990) and the work of Bandura (1986). The reciprocal determinism model was based on Cooper's assertion that safety culture might be created or enhanced through the deliberate goal-directed manipulation of organisational variables which were thought to affect safety management practices. If safety culture was visualised as the super-ordinate goal, therefore, sub-goals could be created to direct employee attention and actions to the management of safety (Cooper, 2000). However, this view might be criticised for being over deterministic, underplaying the inherent complexity of organisations and cultures, and resting upon the capacity to identify suitable goals that employees support.

Cooper's model (shown in Figure 2) was said to have reflected a holistic and dynamic approach to the consideration of safety within an organisation, reflecting thinking within the human factors domain. In this model, Cooper (2000) stated that a reciprocal relationship between the person, the job (or task) they perform, and the situation (context) existed. Each aspect of the model was proposed to affect the remaining two aspects, however Cooper (2000) cautioned that this may not occur simultaneously, so should not be interpreted as static in its causality. Cooper's (2000 p118) definition of culture reflected the main aspects of the model shown in Figure 2 as being *"reflected in the dynamic reciprocal relationships between members' perceptions about, and attitudes towards, the operationalisation of organisational goals; members' day-to-day goal directed behaviour; and the presence and quality of the organisation's systems and sub-systems to support the goal-directed behaviour".*

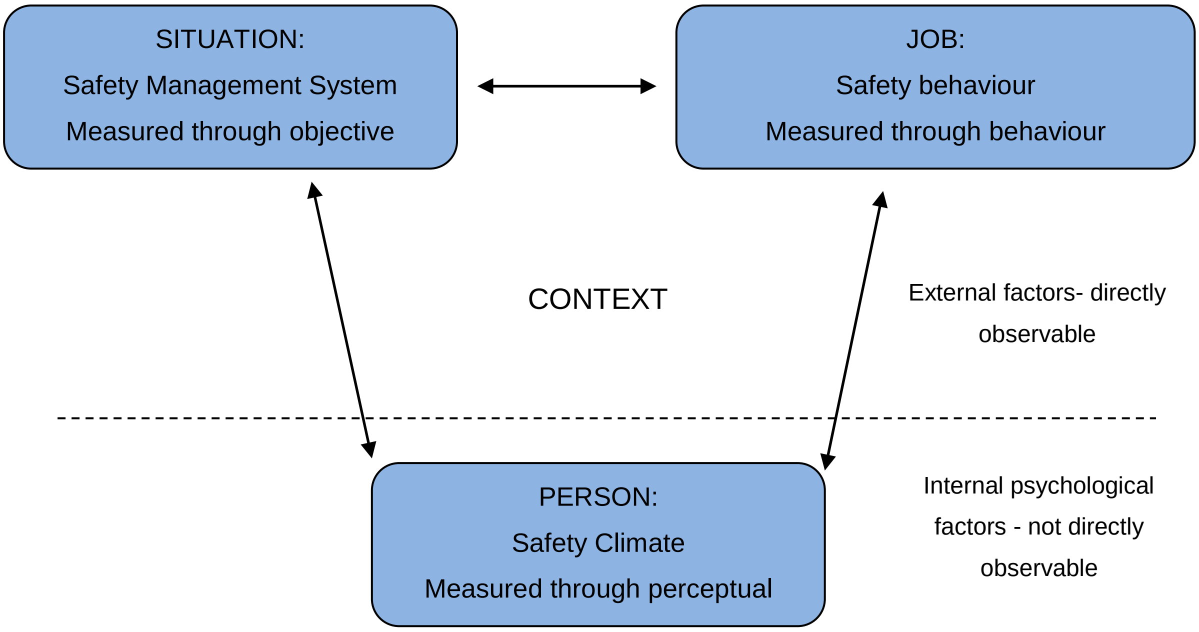

Figure 2. Reciprocal safety culture model (adapted from Cooper, 2000).

Cooper (2000) claimed that the strengths of the reciprocal safety culture model were that it supported a triangulated measurement methodology for multi-level analysis, that it allowed a multi-faceted view of safety culture and that it represented an integrated way of thinking about the processes that impact on safety culture. A key tenet of this model was that to effect change, each of the different factors should be considered; trying to change attitudes with no requisite change in organisational systems or ignoring the effect that change initiatives may have on people's attitudes or behaviours was said to be likely to fail (Cooper, 2000).

This model has been influential in studies developing behavioural measures of safety culture (such as the Safety Organising Scale, Vogus & Sutcliffe, 2007), known broadly as behavioural based safety (BBS). Unlike previous safety culture models, Cooper's reciprocal determinism model has received some empirical support. Fernandez-Muniz et al. (2007) interpreted Cooper's model as identifying management's commitment to safety (person), employee involvement (behaviour) and policies and procedures (situation) as being mutually dependant. Using a multi-dimensional questionnaire, including measures of safety climate, self-reported injuries, lost time and motivation, these authors attempted to test the nature of the relationship between the elements of the model. Management commitment was found to have a significant, direct and positive influence on both employee involvement and the safety management system (SMS) whilst the SMS significantly influenced employee involvement. The SMS and employee involvement were found to have a significant impact on safety performance (Fernandez-Muniz et al., 2007).

Utilising Cooper's model, it is reasonable to suggest that accident prevention might be achieved through attitude modification (person/safety climate domain) through behaviour modification (behaviour domain) or through structural modification (situation/SMS domain). In a meta-analysis of intervention studies using a range of these measures, Lund and Aaro (2004) concluded that behaviour modification programmes showed mixed results; those aimed at a single behaviour were more effective, as were studies using rewards. Changes to structural/situational factors were seen to be most effective with regard to influencing behaviour, with regulation, product modification and enforcement having a generally strong positive effect on reducing accidents and injuries (Lund & Aaro, 2007).

The reciprocal nature of the model was not, however empirically supported, as behavioural modification (behaviour) was often not accompanied by changes in attitude (person) and changes to the situation sometimes negated the behavioural element by directly influencing the risk situation (Lund & Aaro, 2007). Cooper's (2000) reciprocal model of safety culture has therefore received some empirical support for the person (i.e. safety climate) and behaviour sections of the model. However, criticisms of Cooper's (2000) model have related to the resource intensive nature of the behavioural observation aspect (Anderson, 2005) and the tendency to focus on behavioural aspects to the detriment of (less easily observable) process factors. Indeed, numerous elements in complex socio-technical environments do not lend themselves to observation, potentially limiting the application of Cooper's model of safety culture.

2.4.4 Grote and Kunzler's Socio-Technical Model

Grote and Kunzler (2000) criticised safety culture models for a lack of integration with general models of organisations, and lacking a connection between safety-related and more general aspects such as job and organisation design. By separating safety from the rest of the organisation's functions, these authors argued that important influences on safety would be ignored. Grote and Kunzler (2000) therefore proposed a socio-technical model of safety culture that they claimed linked safety management and safety culture with more general organisational design. The socio-technical model suggested that there were various material characteristics of the organisation (such as ways of integrating safety into organisational structures and processes) and immaterial, intangible characteristics such as norms, values and beliefs.

Many of the concepts articulated in Grote and Kunzler's model appear to have been drawn from Schein's (1990) early work; the material characteristics (which are visible and difficult to decipher) were akin to Schein's (1990) artefacts and Grote and Kunzler's (2000) value consciousness/norms are akin to the underlying assumptions (i.e. hidden and taken for granted). In an attempt to support this model empirically Grote and Kunzler (2000) developed a questionnaire, utilised in conjunction with interviews and workplace observations, to analyse safety management and safety culture. The questionnaire contained items which were very similar to those contained in safety climate questionnaires. In conclusion, this model is not markedly dissimilar to Schein's or Cooper's models, and has not received any further formal testing. Choudhry et al. (2007) criticised the socio-technical model for being schematic, saying it lacked any mechanism to improve and assess safety culture. However, arguably the same could be said for most of the safety culture models described so far.

2.4.5 Safety Culture Maturity Models

Based on Westrum's (2004) typology of cultures (pathological, bureaucratic and generative, with Fleming, 2001, later adding reactive and proactive levels), several authors (Fleming, 2001; Hudson, 2007; Parker et al., 2006) have proposed that organisations might exist on a continuum of safety culture 'maturity' (which equate to a continuum of bad to good, expressed in various forms). According to the safety culture maturity model organisations should aim to increase their maturity from pathological to generative safety culture on a number of different safety dimensions. These dimensions have variously included aspects of the SMS (reporting systems, safety audits, work organisation), safety climate (attitudes, commitment) and some apparently cultural factors (behaviours that get rewarded, who causes accidents) against which the organisation is scored on the maturity scale. The intention of the safety culture maturity model was that tools developed using it would be used by employees to generate discussion about their organisation's safety culture and would then be provided with a 'road-map' on how to improve safety (Fleming, 2001).

While intuitively attractive, safety culture maturity models have had very weak empirical support. Lawrie et al. (2006) presented some evidence of the internal consistency of a sub-set of seven safety-related categories by forming a questionnaire which reflected the safety culture maturity framework. These authors claimed to demonstrate some reliability for a sub-set of scales. Furthermore, they suggested that their findings showed some discrimination between the highest (generative) and lowest (pathological) maturity levels. However, the sample size (59 participants) of this study appeared inappropriate for the statistics applied (principle components analysis on over fifty items) and the results are decidedly mixed. The authors themselves suggested that, in an industry with some regulation, pathological indicators might already be removed, whilst generative indicators might be unrealistic and unattainable (Lawrie et al., 2006).

Filho et al. (2010), tested the concept of a safety culture maturity model in a study based in Brazil, and reported high correlations between questionnaires and interviews on a sample of 23 people. However, there was little information within the publication regarding how this was completed, without which reproducing these findings would be challenging. Fleming (2001) cautioned the use of the safety culture maturity model as a diagnostic tool until it had been tested empirically, which has not yet been undertaken. Beyond creating a focal point for discussion, the utility of this model as a basis for understanding safety culture is suggested to be limited to date.

2.4.6 Reason's Elements of Safety Culture

When considering the causes of organisational accidents, Reason (1997) identified four components that he suggested comprised an 'informed culture', where the organisation effectively shares information and actively supports safety. This has often been cited as a model of safety culture, although Reason does not directly suggest this himself. These components included:

1. A reporting culture, where people readily report problems, errors and near misses.
2. A just culture, where people are encouraged and supported to provide safety related information in a context where acceptable and unacceptable behaviour is made clear.
3. A flexible culture, which can adapt to changes while retaining a safety focus.
4. A learning culture, where the organisation is willing and able to draw conclusions from safety information and uses this knowledge to improve safety.

This model is intuitively appealing, particularly to safety managers, for whom management of information in the form of safety reports is often a key aspect of the role. This model has subsequently been adopted by numerous organisations such as the National Aeronautics and Space Administration (NASA) (whose most recent strap-line is *"NASA safety culture...it's in our DNA"[4])*. However, despite being widely used, this model has been criticised for being in many respects underspecified (Cooper, 2000) and is not yet empirically supported. This may, in part, be due to how Reason's cultural components are defined and their lack of amenability to measurement. While increasingly used in accident analyses, Reason's model provides only a narrow focus around organisational

[4] https://sma.nasa.gov/sma-disciplines/safety-culture

culture. Reason's model was advocated in the Nimrod Review (Ministry of Defence, 2009) and was also therefore the basis for the model of safety culture set out by the military aviation regulator (Manual of Air Safety, Military Aviation Authority, 2014a) described in Chapter 1.

2.4.7 Summary

The preceding review of safety culture and climate models revealed that no single model appeared to adequately account for the complexity of the concept, nor were any sufficiently empirically supported. It was Guldenmund (2000) who described these theoretical models as providing direction on the content of safety culture and broad categories of interest, rather than forming theoretical models *per se*. The various safety culture models detailed here reflected some agreement in that various workplace factors, as well as individual views and shared experiences, are thought to interact in a dynamic and complex fashion to influence safety behaviours, which can in turn impact the workplace and shared views. Cooper's reciprocal determinism model (2000) appears to be the most holistic theoretical model, while Reason's (1997) model is noted to be the one most widely cited within an increasing number of accident reports which cite safety culture as a causal factor. Schein's multi-layered model of culture is perhaps the most reflective of many culture/climate definitions, with artefacts and espoused beliefs being congruent with the conceptualisation of safety climate and the underlying assumptions congruent with the conceptualisation of safety culture.

2.5 Dimensions/constructs of Safety Culture and Climate

Section 2.4 detailed some of the core concepts and constructs around which researchers in the safety climate/culture literature appear to agree. Suggestions that safety climate/culture is a multi-dimensional phenomenon (Flin et al., 2000; Guldenmund, 2000) have consistently been supported through the development of multi-dimensional safety culture/climate scales, as well as through identification of various themes and constructs in the qualitative safety literature. However, despite considerable research there is, as yet, no conclusive answer to Flin et al.'s (2000) question as to whether these dimensions are generic features of safety culture, or should be considered context-specific.

The following section outlined findings from both quantitative and qualitative studies of safety culture and climate to explore which dimensions or constructs they may be comprised of. It should be noted that the following section refers to both culture and climate in the context of how the original authors have applied the terms. Where authors have specifically addressed either, this will be stated. The methods used to gather quantitative and qualitative data are considerably different, and so it is difficult to directly compare results from qualitative and quantitative studies. There are several key reviews which have considered the similarities and differences arising from the numerous quantitative safety culture or climate tools (such as Choudrey et al., 2007; Clarke, 2000; Farrington-Darby et al., 2005; Flin et al., 2000; O'Conner et al., 2011b; Seo et al., 2004; Weigmann et al., 2004). These reviews have not typically included any qualitative studies. Therefore, the current review attempted to address this shortcoming by not only considering quantitative research findings (Table 1) but also results from qualitative research (see Table 3). In addition, a number of studies which proposed safety culture dimensions derived from observations of high reliability organisations (HROs) were critiqued as well (see Table 4).

2.5.1 Quantitative

Early quantitative studies predominately considered safety climate, although some contemporary studies also describe the use of quantitative measures of safety culture. Studies of safety climate, predominately taking a positivist orientation, often focused on trying to capture a universal set of dimensions or constructs. Zohar's (1980) safety climate questionnaire was the first of its kind; the forty items were based on a review of safety literature. Subsequent analysis of these items revealed eight safety climate dimensions; training programmes, management attitudes toward safety, effect of safe behaviour on promotion and social status, perceived risk at the workplace, effects of work pace and status of the safety officer and safety committees (Zohar, 1980). Zohar's work formed the basis for a number of subsequent safety climate measures, such as the NOSACQ-50 (Kines et al., 2011) and the Safety Attitudes Questionnaire (Sexton et al., 2006). Attempts to replicate Zohar's (1980) dimensions have, however, met with limited success (Brown & Holmes,1986; Coyle et al., 1995; Glennon, 1982).

Table 1.

Summary of common safety culture/climate dimensions identified in systematic reviews.

Authors	Notes	Dimensions/categories
Flin et al. (2000)	Meta-analysis of 18 safety climate surveys, in which 100 dimensions were thematically analysed; this led to a small number of common themes across all studies.	Management/supervision Safety system Risk Work pressure Competence
Clarke (2000)	Review of 16 safety climate/culture studies (many of which were common with Flin et al., 2000).	Work task/work environment Personal involvement and responsibility Management attitudes Safety management system Management actions
Weigmann et al. (2004)	Review of safety culture literature up to 2004, refers to 'organisational indicators' of safety culture, rather than dimensions for aviation applications.	Organisational commitment Management involvement Employee empowerment Reward systems Reporting systems
Seo et al., (2004)	Systematic review of 16 safety culture/climate studies to inform development of safety climate tools.	Management commitment/supervisor support Employee participation Work pressure Hazard level Competence
Farrington-Darby et al. (2005)	Literature review for rail safety applications.	Management Immediate supervisors Individual and behavioural factors Reporting systems Rules and procedures Communication Sub-cultures
Choudrey et al. (2007)	Literature review for construction safety; authors suggest that positive safety culture comprised of these components.	Management commitment to safety Management concerns for the workforce Mutual trust and credibility Workforce empowerment Continuous monitoring and corrective action
O'Conner et al. (2011b)	Review of commercial and military aviation safety culture/climate research.	Management/supervision Safety systems Operational personnel Procedures/rules Communication Resources Risk Training/education

After a thematic analysis of over one hundred dimensions identified in eighteen safety culture studies, Flin et al. (2000) reported a reduced set of thirty-five dimensions. Of these, they identified five as occurring in more than one third of the studies (see Table 1). In parallel, Clarke (2000) reviewed many of the same studies as Flin et al. (2000), but reported some additional 'core' dimensions to Flin et al., including work task/work environment and personal involvement /responsibility (Table 1).

Weigmann et al. (2004) summarised five 'global' components or indicators of safety culture. However, uniquely, this review also identified dimensions of organisational commitment, reward systems and reporting systems. Seo et al.'s (2004) review highlighted five common dimensions, of which employee participation had not been previously identified as a core component. Additional core dimensions were then added in 2005 by Farrington-Darby et al., including communication, rules procedures and supervisor relationship with subordinates (see Table 1). Choudrey et al.'s (2007) review cited mutual trust and credibility as well as continuous monitoring and corrective action as core dimensions while finally, O'Conner et al. (2011b) reported operational personnel, resources and training/education as core dimensions not previously been made explicit in previous reviews (Table 1).

Each of the seven studies summarised in Table 1 reviewed a similar literature base, however each proposed at least one unique dimension. To some degree this may be attributable to differences in the method and focus of each; Flin et al. (2000) thematically analysed their reviewed dimensions, while the remainder of the studies shown in Table 1 identified core dimensions by the frequency with which they were identified. The later reviews would also inevitably have drawn from a greater number of studies than earlier reviews. Some of the differences may further be down to interpretation of the dimensions, which were not always uniformly described within source studies (Guldenmund, 2000). It is interesting to note, however, the variety in 'core' concepts which have been identified across the systematic reviews. The dimensions that were identified across multiple reviews included:

- Management/supervision
- Safety management system
- Pressure
- Hazard or risk level
- Communication
- Procedures/rules.

This may indicate that there are likely to be some dimensions of safety culture/climate which reflect commonality across a variety of sectors and organisations. However, beyond these, there were a notable array of dimensions identified that did not fall into the common dimensions detailed above; these are summarised in Table 2. Where publications appeared in more than one systematic review, these are only cited once.

Table 2.

Summary of unique/uncommon safety culture/climate dimensions identified in systematic reviews.

Authors	Cited authors-organisational sector	Dimensions/categories
Flin et al. (2000)	Lee (1998)-nuclear reprocessing	Job satisfaction Design
	Cox and Cox (1991)-gas company	Scepticism Personal immunity
	Rundmo (1992, 1994)-oil company	Sensation seeking Time independence
	Mearns et al. (1997)-offshore oil and gas	Work clarity Promotion
	Zohar (1980)-manufacturing	Social status
	Williamson et al. (1997)- manufacturing	Fatalism/optimism
	Niskanen (1994)-road construction	Work value
Clarke (2000)	Donald & Canter (1994)-chemical processing	Passive and active safety behaviour
	Alexander, Cox & Cheyne (1994)-offshore oil and gas	Conflict and control Overconfidence in own safety
	Mearns et al. (1998)- offshore oil and gas	Personal interest and satisfaction with job
	Lee (1998)-nuclear	Personal authority
Seo et al. (2004)	Lee & Harrison (2000)-nuclear	Satisfaction with salary General morale Job insecurity Risks of multi-skilling
	O'Toole (2002)-not described	Drugs and alcohol Emergency response Off the job safety
O'Conner et al. (2011b)	Gibbons et al. (2006)-civil aviation	Informal and formal safety system
	Ek & Akselsson (2007)-civil aviation, ground handlers	Justness, flexibility
	Patankar (2003)-civil aviation	Pride in company Professionalism Stress
	Gill & Shergill (2004)-civil aviation	Regulator's role Luck
	Desai et al. (2006)-military aviation	Command and control

2.5.2 Qualitative

Only six qualitative studies of safety culture were identified in the literature; the results of which are summarised in Table 3. Some similarities between some of the elements/dimensions/themes identified in Table 3 and those in Tables 1 and 2 can be seen. These included the safety systems, fatalism, responsibility for safety, trade-off between productivity and safety, communication and the work environment.

Table 3.

Summary of safety culture/climate dimensions identified in qualitative research.

Authors	Study type/population	Elements/dimensions/themes
Brooks (2005)	Ten-week ethnographic study of safety management in Australian commercial lobster fishing industry.	Safety procedures, policies and safety equipment Physical risks and injuries Role and status in social organisation Workplaces as transactional environments Adapting to external environments Power Group boundaries The nature of reality and truth Uncertainty Time Human activity Existence of safety culture

Walker (2010)	Two-year ethnographic study of grain processing organisation.	Fatalism/danger/injury
		Counterculture of safety/ resistance to authority
		Trust
		   Colleagues
		   Contingent workers
		Effects of formal accountability

Szymczak (2014)	Two-year ethnographic study of a hospital's experience of implementing a patient safety program.	Culture as individual behaviour Culture as talk of obfuscation Culture as allocation of responsibility for risk

Nordloff et al. (2015)	Focus group interview study of employees in steel manufacturing organisation, using thematic analysis.	Acceptance of risks
		    Danger tolerance
		    Fatalistic beliefs
		Individual responsibility for safety
		    Low company commitment
		Trade-off between productivity and safety
		    Management expectations
		    Worker expectations
		    Practical obstacles
		Importance of communication
		    Thinking about safety
		    Collaboration between colleagues
		    Reporting incidents
		State of the day and external conditions
		    Nonchalance
		    Routine
		    Low staffing
		    High pace

Blazsin & Guldenmund (2015)	Semi-structured interviews with twenty employees of gas distribution organisation, using discourse analysis.	Group relationship with organisation's safety policy
		    Perceptions of rules
		    Perceptions of risk
		    Perceptions of safety policy
		Perceptions of what a 'good gasman' is
		Relationship between time and safety

Weyman, Pidgeon, Jeffcott & Walls (2006)	Interviews with thirty-eight senior UK railway representatives and interviews/focus groups with five hundred UK railway employees.	Stakeholder relationships Management commitment The Performance Regime Blame and Culpability Knowledge management Organisational learning Resources Morale Homogeneity of culture

2.5.3 Theorised Dimensions

There have been numerous attempts to define the features of a good/positive safety culture (summarised in Table 4). These have typically come from studies of either high reliability organisations (HROs) such as air traffic control, military aircraft carrier operations, or from reviews of organisational preconditions to accidents. INSAG (1991) was one of the first to propose 'universal features' of safety culture based on HROs. These components included individual awareness, knowledge and competence, commitment, motivation, supervision and responsibility. Pidgeon and O'Leary (2000) further suggested that a 'good' safety culture might be promoted by senior management commitment to safety, shared concern and care about hazards, realistic norms and rules about hazards and organisational learning through monitoring, analysis and feedback. Hale's (2000) description of elements required for a good safety culture are similar and included commitment to the importance of safety, worker involvement at all levels, the role of the safety staff, caring trust (employees actively look out for each other), openness in communication, belief in safety improvements and integration of safety into the organisation.

Table 4.

Summary of theorised safety culture/climate dimensions.

Authors	Notes	Dimensions/categories
INSAG (1991)	Suggested 'universal features' derived from observations of high reliability organisations.	Individual awareness Knowledge and competence Commitment Motivation Supervision Responsibility
HSE (1991)	HS(G) 65 - the HSE's 'core elements' for managing effective health and safety. This formed the basis of thinking for the HSE safety climate tool development.	Leadership and Management Competence Worker involvement Risk profiling Legal compliance
Hale (2000)	Commentary on special issue on safety culture, included his elements for a good safety culture.	The importance given to safety as a goal Aspects of safety and priority given to these Involvement of all parties Creative mistrust in the risk control system Caring trust of each other Openness of communication Safety is not just down to individuals Integration of safety thinking into work practice
Pidgeon & O'Leary (2000)	Examining safety culture from the perspective of organisational accident investigation, a 'good' safety culture was reflected by four facets.	Senior management commitment Shared care and concern for hazards Norms and rules about hazards Reflective practice/organisational learning

It is notable that many of the dimensions detailed in Table 4 are similar to those contained in Table 1 and Table 2. Many of the theorised dimensions that comprise a 'good' safety culture are reflected across commonly identified safety climate dimensions (Table 1), with management, leadership, risk, competence and worker involvement appearing key to both empirically derived and theorised models. The challenge with defining a 'good' safety culture as those characteristics which are displayed by HROs (such as several of those in Table 4) is that this becomes seen as an ideal to strive for, which once achieved, will guarantee future safety. However, only a small number of organisations at particular points in time have been studied to generate the theorised dimensions in Table 4, and whether these conditions can persist through an organisation's lifecycle is as yet unknown (Boin & Schulman, 2008). Furthermore, these characteristics have not been definitively tied to the reliability of performance of the organisation (Boin & Schulman, 2008) and the role that these play in creating safety is therefore poorly defined.

2.5.4 Summary

Quantitative research (Section 2.5.1) has shown some degree of consistency in findings and these show particular overlap with the dimensions proposed from the HRO-derived elements (Section 2.5.3). Findings from qualitative safety culture research (Section 2.5.2) have revealed limited dimensions in common with the quantitative/theoretical perspectives in relation to:

- Hazard or risk level; danger/injury (Walker 2010), acceptance of risks (Nordloff et al., 2015), perceptions of risk (Blazsin & Guldenmund, 2015) and allocation of responsibility for risk (Szymczak, 2014).
- Management/supervision; low company commitment and management expectations (Nordloff et al., 2015) and resistance to authority (Walker 2010).
- Communication; workplaces as transactional environments (Brooks, 2005), importance of communication (Nordloff et al., 2015).
- Pressure; adapting to external environments (Brooks, 2005), trade-off between productivity and safety (Nordloff et al., 2015) and relationship between time and safety (Blazsin & Guldenmund, 2015).
- Safety management system; group relationship with the organisation's safety policy (Blazsin & Guldenmund, 2015).

However, there remains a high degree of variability across studies with respect to the additional dimensions which have been identified (see Table 2). Cox and Cox (1991) concluded that differences in the breadth and depth of coverage, variations in researcher judgement of item wording/selection and cross-cultural/inter-industry variations were such that striving for a universal structure was unlikely to succeed. The lack of stability of factor structures in climate measures might also suggest that constructs are prone to vary between study populations which exist in different regulatory, structural and socio-technical contexts (Jeffcott et al., 2006; Reiman & Rollenhangen, 2011). Indeed, while it may be that some aspects are common across industries, this does not suggest that these are the only dimensions which must be measured as this may result in important 'local' issues being neglected (Jeffcott et al., 2006).

2.6 Safety Culture/Climate in Aviation or Military Populations

As there were relatively few published articles in the area of military safety culture/climate research the review was broadened to encompass civil aviation studies as well.

2.6.1 Military Aviation

Command Safety Assessment Survey (CSAS) and Maintenance Climate Assessment Survey (MCAS)

In 1996, the United States (US) Navy, in response to a spate of naval aircraft accidents, began work on ways to measure safety culture to afford insight into why these accidents were happening. From this early research (Baker, 1998) two measures were developed, the CSAS and the MCAS. The former was designed for pilots and the latter for maintenance personnel, with both still in use by the US Navy today. These surveys were originally based on a theoretical Model of Organisational Safety Effectiveness (MOSE) that identified five areas as important in managing risk and reducing accidents in high risk organisations (O'Conner et al., 2011a). These included process auditing (checks to identify hazards and correct safety issues), reward system (expected social rewards and disciplinary actions), quality control (policy and procedures to promote high quality work), risk (identify hazards and control operational risk) and command and control (safety climate, leadership effectiveness, safety management policies).

Baker (1998) used cluster and factor analysis to determine whether the sixty-seven item MCAS clustered according to the five original MOSE components. The factor analysis did not support the original categories, and the survey was reduced to 35 items; further independent testing of the MCAS has subsequently revealed inconsistent results. Stanley (2000) proposed that although an analysis revealed only one factor, each of the MOSE categories was represented within it. However, Brittingham (2006) subsequently contradicted these conclusions, and suggested that the MCAS was inadequate, with questionable validity.

Two published studies have used the CSAS for measuring safety climate; Gaba et al. (2003) compared responses of health care professionals (completing the patient safety culture in healthcare organisation, PSYCHO measure) and naval aviators (completing the CSAS), on aggregated responses to twenty-three items which partially overlapped (the PSYCHO was partly adapted from the CSAS). Gaba et al. (2003) identified differences between the two populations however, these authors did not aim to determine the psychometric properties of the twenty-three items and treated each item as independent, therefore the results should be interpreted with caution (Oppenhiem, 1992).

More recently, Desai et al. (2006) aggregated all sixty-one items from the CSAS into a single measure of safety climate, and used this to explore relationships with Navy mishaps. Limited evidence was found that results from the CSAS related to mishaps (safety incidents). Buttrey et al. (2010), aimed to establish the construct validity of the CSAS, but found that they could not replicate a stable factor structure using the original components, and therefore questioned the validity of the CSAS. High levels of non-random variance were posited as possible reasons for this lack of replication, potentially arising from the fact that participation in the survey was mandatory rather than voluntary. Of the original CSAS items, O'Conner et al. (2011b) retained only twelve items within two factors, personnel leadership and availability of resources.

On balance, few of the latter investigations of the MCAS and CSAS have shown support for the psychometric robustness of either tool. The online portal for these tools suggests that validation work has been conducted in relation to US Navy mishaps. However, this validation has not benefitted from peer-reviewed publication and rests on correlations between survey results and accident rates, the highest of which was -0.175 (Schimpf, 2004).

Australian Defence Force Aviation Questionnaire

In an unpublished PhD thesis, Falconer (2006a) reviewed an attitude questionnaire, the Flight Management Attitudes Questionnaire (FMAQ), which was adapted for the Australian Defence Force (ADF). Falconer (2006a) argued that this measure was not applicable to a military population as it was developed based on a sample of civilian pilots. Based on a synthesis of existing research on organisational behaviour, culture and human factors, Falconer (2006a) proposed a new forty-five item survey based on four *a priori* themes - military efficiency, organisational confidence, adaptive focus and safety perception. Falconer's thesis did not explore the factor structure of the survey, although the *a priori* themes displayed some internal consistency. No published studies could be found which used the questionnaire detailed in Falconer's thesis.

The lack of empirical evidence to support either the reliability or validity of any of these military aviation based safety climate tools dissuaded use of either within the current study, although individual items were considered for inclusion in development of the tool detailed in Chapters 6 and 7.

2.6.2 Civilian Aviation

Diaz and Cabrera (1997) developed an organisational safety climate questionnaire (based on items from existing questionnaires) under five dimensions; strategy/company policy toward safety, company philosophy, individual/group attitude, supervisors/management and level of risk/safety. A principle components analysis of data from three aviation-related organisations resulted in six components; company policy, productivity vs safety, group attitudes, prevention strategies, and perceived safety levels. Besides an overall consistency (Cronbach alpha) of 0.93, these authors did not detail either the items on each dimension or the psychometric properties of each scale.

McDonald et al. (2000) adapted the safety climate scale developed by Diaz and Cabrera (1997), subjecting the original items to factor analysis and item reduction. McDonald et al. (2000) compared different companies and functional groups on mean scale ratings and reported significant differences between groups. Despite the presence of significant differences, however, it was noted that the group sizes varied considerably (334 in one group and 29 in another, for example) and safety climate was considered here to be a one-dimensional scale. Neither the factor analysis nor detail of the items were reported by McDonald et al. (2000), restricting further critique.

Patankar (2003) created the Organisational Safety Culture (OSC) questionnaire, based on items and dimensions from several existing questionnaires. These included the Cockpit Management Attitudes Questionnaire (CMAQ), the Maintenance Resource Management/Technical Operations Questionnaire (MRM/TOQ), and the CSAS (discussed above in Section 2.6.1.1). Subsequent factor analysis identified eight scales; pride in company, professionalism, safety, supervisor trust and safety, effects of stress, need to speak up, safety compliance and hazard communication (Patankar, 2003). The lack of detail regarding the output of this factor analysis made it difficult to critique the psychometric underpinning of this scale, but Pantankar (2003) did use the constituent scales to profile different groups within an aviation organisation.

Gibbons et al. (2006) created a database of over 1000 items from safety climate questionnaires to develop their 81-item Commercial Aviation Safety Survey (CASS). Based on their judgement these authors clustered these items into five dimensions; organisational commitment, management involvement, reward/accountability, pilot empowerment and reporting systems. However, Gibbons et al. (2006) were unable to demonstrate adequate model fit indices and suggested that conceptual overlap between the various scales was to blame.

Evans, Glendon and Creed (2007) developed the Aviation Safety Climate scale using a two-step process. Firstly, a literature review produced several safety themes which were then ranked by ten aviation safety experts in order of importance. Evans et al. (2007) did not detail how many themes were initially included, nor how (or if) agreement between the safety experts was determined. Six themes were taken forward into the questionnaire; management commitment, communication, rules/procedures, shifts/schedules, training, and equipment/maintenance. Secondly, items from other safety climate tools were then matched to these safety themes. A subsequent exploratory factor analysis resulted in a three-factor structure; management commitment and communication (10 items), safety training and equipment (4 items) and maintenance (4 items). This three-factor model was then subjected to a confirmatory factor analysis, initially returning a poor model fit. Iterative re-specification of the model did, however, result in an acceptable model fit. The scale was therefore considered as one of the more psychometrically robust safety climate questionnaires, however the authors did suggest caution in the use of it due to the exclusion of factors such as safety policy, rules/regulations and work pressure. Furthermore the top-down methodology employed during the development of the questionnaire meant that one could not judge the relevance of the proposed themes to the individuals completing the questionnaires, nor determine whether there may be other important factors which were not identified by the researchers.

In a recent meta-analysis of twenty-three aviation safety climate studies (including many of those studies discussed above), O'Conner et al. (2011b) concluded that quality of management and supervision represented the only unifying theme across all studies. Beyond this they cited safety systems, procedures/rules, training/education, risk, communication, resources and operations personnel as additional themes which were common across many studies. These findings were broadly in line with research from other sectors, however, the lack of convergence on a common set of constructs, even within this single sector, was noted (O'Connor et al., 2011).

2.6.3 Summary and Implications for Current Research

The preceding sections have outlined a variety of safety culture/climate dimensions that were identified across a number of sectors, and then specifically focused on military and civilian aviation research. Identification of a core set of generic features of safety culture/climate through several meta-analyses has resulted in some consensus as to features which may be broadly applicable across industries. Use of a core, generic set of dimensions is appealing, particularly to safety managers who might want to profile their own organisations and then 'benchmark' themselves against others in the form of a league table. Inherent in this, however, is the danger that generic approaches may remove the richness of understanding and detail to such a degree so as to make any output lack utility (Guldenmund, 2007; Walker, 2010); one size may not fit all.

The evidence of factor structures which are unstable and vary both across and within industries (Cox & Flin, 1998; Pidgeon, 1998, Guldenmund, 2010a) has been compounded by a lack of consistency in findings or the approach to their exploitation. Some authors have attributed this to methodological issues, including differences in applying measures (Guldenmund, 2000), differences in questionnaire design and item selection issues (Coyle et al., 1995) and researcher-created bias (Coyle et al., 1995). Lee and Harrison (2000) argued that inter-industry differences in structure, purpose and activity might render the quest for a generic factor structure premature.

Beyond methodological issues, some authors have proposed that salient constructs are prone to vary between study populations (Jeffcott et al., 2006; Weyman et al., 2006) and question the existence, or even relevance, of a generic set of defining constructs. Waterson et al. (2010) warned against the dangers of too readily generalising about safety culture and climate across industries with differing characteristics, forms of hierarchy and work practice. In line with earlier concerns regarding safety culture becoming a catch-all concept (Cox & Cox, 1991; Cox & Flin, 1998), the conceptualisation of a general 'ideal' model with core concepts arguably does not take into account differences in the regulatory, structural, socio-technical and historical architecture within which employees operate (Reiman & Rollenhangen, 2011; Weyman et al., 2006). Thus generic tools and a fixation with 'core' concepts could be considered to remove the focus on safety culture being a contextual phenomenon. This does not sit well with many of the safety culture models outlined in Section 2.4 in which context (the work environment) was proposed to play a key role. While it may appear desirable to create a generic tool to apply across organisations, Gibbons et al. (2006) warned that this might not be possible, or desirable, as safety is likely to be closely tied to the structure of the organisation and the work performed there.

The current review of safety culture and climate literature showed a large variety in identified dimensions, particularly when using qualitative methods. These, which have taken a 'bottom up' approach to identifying safety culture factors, may arguably provide a greater level of contextualisation (Cox & Flin, 1998; Weyman et al., 2006; Reiman & Rollenhangen, 2011). While a small number of common 'components' of safety culture/climate have been identified across various studies, these might afford only limited insight into what factors are important in shaping the safety culture of an organisation.

Various tests of the construct, content and concurrent validity (via psychometric testing) of safety culture/climate have been undertaken by researchers during measurement development, however the evidence of predictive validity also requires attention. For organisations to consider allocating resources to collecting information on safety culture or climate, it is important to demonstrate that these measures are related to some form of organisational safety outcome measure. The following section therefore considered the available evidence related to the concepts of safety culture, safety climate and safety performance.

2.7 Safety Culture, Climate and Safety Performance

The validity of safety culture/climate as leading indicators relies on evidence of the relationship between measures of culture/climate and safety performance. Christian et al. (2009) suggested that safety performance may refer to either (i) an organisational metric for safety outcomes, such as injuries, accidents or incidents per year or (ii) a metric of individual safety behaviours. The following sections considered the degree to which these relationships have been empirically supported.

Although often considered 'traditional' measures of safety performance, accident and incident rates have been described as poor performance indicators because they ignore the different levels of risk associated with certain tasks, they suffer from both under and over reporting, are not sensitive enough to show quick changes over time (Choudrey et al., 2007) and are highly chance related. Known as lagging, reactive or downstream indicators, accidents/incidents arguably reflect levels of system failure. In many aviation organisations, the low numbers of occurrences have meant that the utility of these as indicators of safety has been limited (O'Conner et al., 2011a). Many authors (such as Choudrey et al., 2007; Cooper, 2000; Cooper & Phillips, 2004; Flin et al., 2000; O'Conner et al., 2011a) have recommended use of safety culture or climate measures as leading (or proactive, upstream) indicators, in addition to monitoring of lagging indicators. The

Health and Safety Executive (HSE, 2006) defined leading indicators as measures of process or inputs which were vital to delivering desired safety outcomes. Leading indicators have been postulated to rely on current safety activities to determine the success of the safety management system and could, therefore, be said to reflect its functioning (Choudrey et al. 2007).

2.7.1 Safety Outcomes: Accidents and Incidents

The safety culture models in Section 2.4 appear to have made the implied assumption that a positive safety culture would reduce the occurrence of accidents through its effect on safe behaviour (Clarke, 2006). Indeed, the identified presence of safety culture as a contributing factor to major accidents implicitly suggests that a 'better' safety culture may have helped to avert the accident from occurring. However, the literature contains few attempts to link safety culture to safety performance. In contrast, there are several meta-analyses which consider the effect of safety climate on safety performance. For this reason, the following sections will predominately refer to safety climate, other than where cited authors specifically refer to culture.

Organisational Accidents

The predictive validity of safety climate to organisational accidents as outcome measures has not yet been analysed empirically (Antonsen, 2009b), despite its suggested prominence as a causal/contributory factor in major accidents. When one considers the rarity, complexity and unpredictability of organisational accidents it is perhaps unsurprising that a link between these has not been the focus of much research (Yule et al., 2007). Antonsen (2009b) presented a unique, opportunistic case study involving two safety culture surveys issued prior, and subsequent to, a very serious incident. The author concluded that the initial safety culture survey (which depicted benign results) failed to detect the organisational problems later identified in the accident investigation and so suggested that this indicated that the survey provided an incomplete view of the culture.

These findings should be interpreted with caution; it is perhaps ambitious to assume that the views of personnel on their workplace (as gathered during safety culture/climate surveys), even when aggregated, could provide the same overall view (in hindsight) of organisational functioning as occurs during accident investigations. On the contrary, investigators have a broader and deeper view into an organisation than could reasonably be expected of any single individual (with the exception perhaps of select senior management personnel). Although intuitively appealing (and generally assumed in many accident reports), it is perhaps a step too far to expect safety culture/climate surveys to demonstrate predictive validity with organisational accidents. However, there may be utility in examining the link between safety climate and the root causes of these accidents in future.

Occupational Accidents

Occupational accidents have, conversely, received a great deal of attention as outcome measures, with several studies having considered the relationship between safety climate and accidents/injuries. A summary of findings from these studies is contained in Table 5.

Table 5.
Summary of studies considering relationship between safety climate and accidents/injuries.

Relationship	Type	Authors	Result (sig/ns)
SC - accidents	Cross-sectional	Hofmann & Stetzer (1996)	*r*=-0.61 (sig)
	Cross-sectional	Zohar (2000)	*r*= -0.16 (sig)
	Longitudinal	Mearns et al. (2003)	(ns)
	Meta-analysis	Clarke (2006)	*r*=0.22 (sig)
	Meta-analysis	Clarke (2010)	*r*=0.14 (sig)
SC-injury severity	Cross-sectional	Johnson (2007)	*r*= -0.50 (sig)
SC-injury frequency	Cross-sectional	Johnson (2007)	(ns)
SC-injury	Meta-analysis	Beus et al. (2010)	*p*=- 0.24 (sig)
Injury-SC	Meta-analysis	Beus et al. (2010)	*p*=- 0.29 (sig)
Safety performance-accidents	Meta-analysis	Christian et al. (2009)	*pe*=-0.31 (sig)
SC-safety audit scores	Longitudinal	Zohar & Luria (2005)	*r*=0.46 (sig)

p= corrected mean, *r*=correlation, *pe*=path estimate, sig= significant, ns=non-significant.

Table 5 shows a number of significant relationships detailed between safety climate and safety outcomes (Beus et al., 2010; Hofmann & Stetzer, 1996; Johnson, 2007; Zohar & Luria, 2005), although many were typically weak or moderate in strength. Others have shown no significant relationship (Johnson, 2007; Mearns et al., 2003). Interestingly, when Beus et al. (2010) concluded that injuries were predictive of safety climate (*p*=-0.29) to a slightly higher degree than safety climate was predictive of injuries (*p*= 0.24), suggesting that employees may 'recalibrate' their perceptions of organisational safety following an injury. Several authors have advised against attempts to use accidents/injuries recorded in incidents management systems as outcome measures as these often have acknowledged under-reporting (Cooper, 2000; DeJoy 1994; Thompson et al., 1998) and the limitation of common method bias (Hofmann & Stetzer, 1996).

2.7.2 Safety Behaviour

In contrast to outcome performance measures such as accidents/incidents, which Beus et al. (2010) argue may indicate the absence of safety, employee safety behaviours may be more easily observable, and infer the presence of safety. As most accident models now attest, an array of organisational factors have been implicated (Pidgeon & O'Leary, 2000; Reason, 1997; Taylor et al., 2015) and, therefore, a lack of accidents may simply indicate that these factors have not yet combined to result in an event. Non-compliance with procedures may be routine in organisations where the incident rate is low, yet this low incident rate does not mean the organisation is somehow 'safe'. Unsafe behaviour (when observable), either volitional or not, is thought to imply a greater likelihood of adverse events, and thus an absence of safety (Cooper & Phillips, 2004). Safety behaviours have been separated into several types, including:

1. Safety compliance, which involves carrying out prescribed activities such as following procedures (Griffin & Neal, 2000),
2. Safety participation, which involves voluntary safety related behaviours such as helping co-workers (Clarke, 2006),
3. Safety motivation, which refers to an individuals' willingness to apply effort to demonstrate safe behaviour and
4. Standards of safety knowledge, i.e. knowing how to work safely (Christian et al., 2009).

Table 6 contains a summary of findings from studies which have considered the relationship between safety climate and safety behaviours. This showed that safety climate was positively associated with safety behaviour across most studies (Clarke, 2010; Hofmann & Stetzer, 1996; Johnson, 2007; Zohar & Luria, 2005), but not all (Glendon & Litherland, 2001). Relationships have also been demonstrated between safety climate and compliance (Clarke, 2006; Griffin & Neal, 2000), participation (Clarke, 2006; Griffin & Neal, 2000), safety knowledge and safety motivation (Christian et al., 2009; Neal et al., 2000).

Table 6.

Summary of studies considering relationship between safety climate and accidents/injuries.

Relationship	Type	Authors	Result (sig level)
SC-safety behaviour	Cross-sectional	Hofmann & Stetzer (1996)	*r*=-0.66 (sig)
	Cross-sectional	Glendon & Litherland (2001)	(ns)
	Longitudinal	Zohar & Luria (2005)	*r*=0.38 (sig)
	Cross-sectional	Johnson (2007)	r=0.78 (sig)
	Meta-analysis	Clarke (2010)	*r*=0.31 (sig)
SC-compliance	Cross-sectional	Griffin & Neal (2000)	*pe*=0.57 (sig)
	Meta-analysis	Clarke (2006)	*r*=0.43 (sig)
SC-participation	Cross-sectional	Griffin & Neal (2000)	*pe*=0.75 (sig)
	Meta-analysis	Clarke (2006)	*r*=0.50 (sig)
SC-safety knowledge	Cross-sectional	Neal et al. (2000)	*pe*=0.58 (sig)
	Meta-analysis	Christian et al (2009)	*pe*=0.24 (sig)
SC-safety motivation	Cross-sectional	Neal et al. (2000)	*pe*=0.43 (sig)
	Meta-analysis	Christian et al. (2009)	*pe*=0.45 (sig)

p= corrected mean, *r*=correlation, *pe*=path estimate, sig= significant, ns=non-significant.

The relationships shown in Table 6 tended to be stronger than those detailed in Table 5, suggesting that there may be a more definitive link between safety climate and safety behaviours, than with outcome measures such as accidents and injuries. Christian et al. (2009) hypothesised that safety behaviours (knowledge and motivation) may moderate the relationship between safety climate and safety outcomes, and tested this hypothesis using a meta-analysis of 477 research articles. Safety climate was found to be positively related to safety knowledge and motivation and that both were related to safety performance which, in turn, was moderately positively related to the outcome measures of accidents and injuries. Christian et al. (2009) concluded from this that workers could be trained and supported through positive safety culture to influence safe behaviour and ultimately therefore lead to fewer accidents and injuries.

More recently, a review paper by Beus et al. (2015) synthesised findings from 697 research articles related to indicators such as safety behaviour. These authors concluded that there was strong evidence to suggest that an individual's safety knowledge and motivation positively impacted their safety behaviours. Context factors, such as the job, safety culture/climate and leadership, were found to be moderately related to knowledge and motivation while both previous accident experiences and personal attributes were only weakly related to safety knowledge and motivation (Beus et al., 2015).

Summary

In summary, although early empirical attempts to discern a link between safety climate and safety outcomes such as accidents and incidents were somewhat mixed, with weak to moderate relationships (see Table 5., there is increasing evidence to suggest that safety climate is an antecedent to individual safety behaviour, including safety compliance and safety participation (see Table 6). Meta-analyses of empirical studies have however shown that this relationship may be moderated by other variables such as safety knowledge and motivation (Beus et al., 2010; Christian et al., 2009). The preceding findings would suggest that the safety culture/climate concepts have shown some relationship with safety performance outcome measures, whether conceptualised as organisational safety outcomes or individual safety behaviours and may therefore have merit as leading indicators of safety. Consequently, it was important to further consider how this information about safety culture/climate has been used within organisational risk management to enhance organisational learning.

2.8 Safety, Risk Management and Organisational Learning

At the centre of the concept of safety culture, Pidegon (1998) theorised, is the way in which information about safety, risk and danger are managed within organisations. There is a need to selectively gather high quality information, amongst the inevitable noise of organizational day-to-day functioning, in response to an uncertainty about risks and hazards (Pidgeon, 1998). This information was considered useful for learning from incidents and other relevant experiences, a process known as 'organisational learning'. Organisational learning is a safety-relevant goal; to meet this objective the organisation must have a means by which to achieve this (i.e. incident reporting/analysis system) and supportive social arrangements (e.g. a shared understanding of how blame and retribution are handled). However, learning is often said to be hampered by the inability to cope with the vast amounts of data and meta-data which require collating and analysis (Pidgeon, 1998).

Safety related information may variously be gathered through mechanisms such as safety management audits, analyses of accident/incident databases, analyses of technical issues and through safety culture/climate measures. Indeed, each may form a partial view of the whole state of safety, with culture/climate thought to reflect an important aspect of the reality of working life in the organisation (Lee & Harrison, 2000). Given that not all failure modes can be anticipated in advance, research into high reliability organizations has suggested that culture somehow 'fills in the gaps' in formal procedures in complex environments (such as air traffic control or aircraft carriers, Pidgeon, 1998).

Organisations are rarely static - they adapt to changes in local conditions, are influenced by previous events and are shaped by both leaders and employees (Reason, 1998). To adapt and improve, organisations typically try to learn from what works, and what does not. Allegorically, Reason (1998) referred to safety culture as the 'engine' which drives organisations toward learning to prevent operational hazards. Arguably, an organisation may demonstrate some commitment to safety by investing resources not just in collecting the information relating to how it might learn, but further in enacting this learning process by using the information to make changes to improve safety.

In this way, this thesis would argue, organisations can collect information from which they can learn by gaining insight into the assumptions and beliefs that employees have about safety and how this interacts with the organisational structures and processes. Safety does not operate in a vacuum, and an appreciation of the wider non-safety related activities, processes and systems are required (Cooper, 2000), particularly in systems where safety may be a dominant, but perhaps not overarching, goal. As described by Aurino (2000), an unacceptable risk for one organisation might be completely acceptable to another, supporting the suggestion that there is a strong cultural element related to safety activities.

The premise that volitional risk taking might reflect prevailing safety standards and norms cited within risk management literature has obvious links to the area of safety culture/safety climate (Weyman et al., 2003). A traditional focus on understanding individual risk perception has given way to a broader focus on organisational structures and their impact on safety behaviour (Weyman et al., 2003). Contemporary views of risk-taking have acknowledged that, despite an intuitive conclusion that risk taking is driven by a lack of risk understanding, there is evidence to suggest that this conclusion is too simplistic (Weyman et al., 2006). Rather, embodied within the safety culture/climate literature is the implied importance of a broader range of influences which give direction as to what behaviours are acceptable and therefore have the potential to impact individual and organisational decision making and risk taking (Aurino, 2000). Studies showing differences in safety perceptions amongst sub-cultures within organisations (Ostberg, 1980; Weyman & Clarke, 2003) have been seen to support the suggestion that divergent conceptualisation and understanding of risk may interact with contextual factors to create different perceptions (Weyman et al., 2003).

2.8.1 Military Risk Management

The goals of military organisations are realised by balancing the safety of operators and the system with hazards that are often extreme and unpredictable (Falconer, 2006b). Combined with the strict hierarchical structure, these conditions make military organisations unlike civilian industry, in which much of the safety research has been based; this is discussed in more detail in Chapter 3. Understanding attitudes to risk and safety in the military is thought to be essential as an important aspect of military training is to be able to deal effectively with potential dangers (Börjesson et al., 2011). A positive attitude toward safety and willingness to take risk are both compatible and desirable in military personnel (Börjesson et al., 2011), but this must be reconciled with legislative and regulatory requirements to reduce risks to as low as is reasonably practicable (ALARP) when dealing with proposed or existing hazardous systems. There are few studies relating to how risk and safety in military organisations might compare to civilian counterparts and given these fairly unique circumstances, and their potential influence on safety and understanding of risk (Turner & Gray, 2009), it is of theoretical interest to consider characterisation of safety culture/climate in a military organisation.

2.9 Critical Findings

- There is limited shared agreement regarding the theoretical basis of the safety culture and climate concepts. However, various workplace factors, as well as individual views and shared experiences, are thought to interact in a dynamic and complex fashion to influence safety behaviours. These, in turn, can reciprocally impact the workplace and shared views on safety.
- There is ongoing debate as to whether the terms safety culture and safety climate should be separated or used interchangeably. Within this thesis they are taken to represent two interpretations of essentially the same phenomenon, however these concepts are separated in terms of the use of different research methods to investigate, explore and understand them.
- While a component related to management commitment to safety is the only component of safety culture/climate which has been identified across all research studies, there is a wider range of potentially unique and important dimensions/constructs which may be central in understanding safety within organisations (detailed in Section 2.5).
- Context has increasingly been acknowledged to be an integral factor when considering safety culture and climate, as has the importance of local issues on employee safety behaviour.
- To date, military safety climate measures have been developed utilising a theoretical, top down approach (Section 2.6). Resultant factor structures from these

measures have been shown to be unstable, with little psychometric integrity or empirical support for the proposed theoretical models.

- Safety climate has been shown to be significantly correlated with individual safety behaviours, and to a lesser degree safety outcomes such as occupational accidents/injuries.

Chapter 3: Methodology and Research Design

This chapter details the purpose of the research, along with the aim and arising objectives. This is followed by an overview of the epistemological and theoretical underpinnings of the research design. The case is made for the merits of adopting a mixed methods approach with respect to the methodological strengths of triangulation. Finally, a description of the rationale for the research and the contribution of the thesis to knowledge in the safety culture and safety climate domain is given.

3.0 Introduction

Although safety climate has the longer research tradition, the term safety culture has become more embedded in modern safety management lexicon. In many cases safety culture has been used as a broad brush term in an attempt to capture the socio-technical aspects within organisations which shape human behaviour but, in doing so, has been said to run the risk of being so inclusive as to lose conceptual meaning (Cox & Cox, 1991; Cox & Flin, 1998; Moran & Volkwein, 1992). There is often little differentiation between the concepts and measures of safety culture and climate (Diaz-Cabrera et al., 2007; Grabowski et al., 2010; Morrow et al., 2014; Varmazyar et al., 2016), thus they have been described as ambiguous (Baram & Schoebel, 2007). With respect to measures, it has been observed that while an array of measurement tools have been developed, there is modest consistency in either their content or exploitation (Cox & Flin, 1998; Pidgeon, 1998).

Despite a significant body of empirical investigation, the scientific insight into the constructs of safety culture and safety climate has not kept pace with increased applied interest in the field (Guldenmund, 2007). Research methodologies vary widely within published studies, seemingly reflecting divergent conceptual understandings and characterisations of culture and climate. Whether researchers and practitioners intend to either measure or provide deep insight into the concepts appears to have affected method choice (Jung et al., 2009), although the paradigm underpinning this choice is often not made explicit (Guldenmund, 2010a). The review of the relevant literature (Chapter 2) highlighted some shortcomings of the approaches used in the past to develop safety culture or climate tools in the military aviation context, and the current chapter considered the potential for a military sample to provide unique insight into the concepts of risk decision making, safety culture and safety climate.

3.1 Purpose of Research, Aims and Objectives

The purpose of the current research was to contribute to the safety culture and climate literature, while providing the sponsor organisation (the RN's FAA) with practical knowledge and insight. The aims therefore were twofold:

1. To explore and characterise the effects of safety culture on decision making in the presence of risk in the FAA.
2. From the perspective of organisational learning, to achieve enhanced resilience to failure by exploring the scope for developing sector-specific quantifiable leading indicators with the capacity to detect weaknesses in safety climate and identify priorities for improvement.

To achieve these aims the research involved the following objectives:

1. Undertake a review of published findings on organisational culture and climate, focusing specifically on safety culture and climate and its relationship with safety performance and risk management. Existing military and civil aviation research were of particular interest for this review.
2. Undertake a qualitative study of military aviation personnel's perspectives of influences on safety and risk decision making to provide insight into the safety culture.
3. Compare the performance of alternative methods of ranking personnel beliefs on the relative salience of influences on risk decision making in the FAA to determine the degree to which the method used may influence the rank order of these influences.
4. Informed by, and triangulating insights from 1, 2 and 3, develop a quantifiable personnel survey to explore the underlying factor structure of variables impacting on safety climate.
5. Validate the factor structure identified in 4 using confirmatory analysis techniques, based on a second sample of personnel.
6. Explore the scope for developing a set of construct scales from the factor structure identified in 5 to produce a measure of FAA safety climate.
7. Using the scales developed at 6, explore and profile safety climate across a range of FAA demographics.

3.2 Research Design

Research is a systematic investigation whereby data are collected, analysed and interpreted with the purpose of understanding, describing, predicting or controlling phenomena that are influenced by the researcher's theoretical framework (Mertens, 2005). This theoretical framework, or paradigm, influences the way that knowledge is studied and interpreted and shapes the intent, motivation and expectations of the research (Bogdan & Biklen). Paradigms are characterised through both their epistemology, which is the perceived relationship with the knowledge being discovered, and their methodology, which is the strategic approach one uses to discover this knowledge. The perspective adopted within this thesis reflected consideration of the relative merits of positivism, interpretivism and pragmatism, and the associated implications for methodology, with respect to their fit with the subject matter and potential for achievement of the research aims. These considerations were informed by precedents within the safety culture and climate research domains. While it is acknowledged that other paradigms exist (Mackenzie & Knipe, 2006), these were not considered applicable to the current thesis, and so were not discussed here.

3.2.1 Epistemology and Methodology

The following account summarised how contemporary safety culture and climate research variously reflected alignment with positivist, interpretivist and pragmatic perspectives.

Positivist Paradigm

The positivist paradigm assumes that an objective reality exists independently of the researcher, reflecting a *"deterministic philosophy"* (Creswell, 2003 p7) in which causes lead to effects or outcomes (Mackenzie & Knipe, 2006). Positivist research generally aims to test pre-conceived theories or propositions through systematic observation and measurement, often with the aim of predicting or controlling the phenomena under investigation (Creswell, 2003). The emphasis on quantification reflects the desire to compare, contrast and demonstrate causal effects, using standardised statistical and/or mathematical methods to determine the strength and generalisability of derived relationships (Cabrera et al., 1997; Clarke, 2006; Cox & Cox, 1991; Glendon & Litherland, 2001; Zohar, 1980). Given the predominance of organisational psychology-based research in this area, many studies of safety culture and climate, particularly so in the case of climate, reflect a positivist orientation (Guldenmund, 2010a).

Adopting the positivist approach, safety culture is characterised as the product of individual and group values, attitudes, competencies and patterns of behaviour regarding safety (Olsen et al., 2009), and is viewed as an independent variable (Maull, Brown & Cliffe, 2001) that influences safety-related outcomes. The tendency of research conducted within this paradigm has been to focus on the detection (good or bad) and strength (strong or weak) of a particular feature of culture (Schultz & Hatch, 1996), which allowed consideration of normative differences between groups (Edwards et al., 2013), thus having the potential to highlight areas of concern. Viewing safety culture from a positivist viewpoint has been particularly useful for safety management professionals as it suggests that this is something that can be quantified, monitored and directed in order to lead to positive safety behaviour; in effect, a risk reduction strategy (Glendon & Stanton, 2000). Support for this approach has been evidenced in the empirical links between safety climate and behaviour (Beus et al., 2010;Christian et al., 2009). However, critics argued that this perspective diluted and over-simplified the concept of culture (Antonsen, 2009; Edwards et al., 2013), often assuming that an organisation has 'a' culture, rather than plural cultures, which can be defined using a universal set of variables. Others have argued that cultures are unique and only through deep immersion in the organisation can this hope to be uncovered (Chatman & O'Reilly, 2016).

Interpretivist Paradigm

In contrast to the positivist paradigm, the interpretivist paradigm considers knowledge and consciousness to be constructed by scientists, rather than deriving from the world, and that subjective meaning plays a crucial role in social actions (Walliman, 2006). Studies underpinned by this paradigm typically have the intention of understanding human experience (Cohen & Manion, 1994) within a socially constructed reality (Mertens, 2005). Here, the researcher and their object of inquiry are inseparable and the researcher's values influence their scientific inquiry (Lincoln & Guba, 1985). Often used to generate theory through a pattern of meaning (Mackenzie & Knipe, 2006), knowledge derived within this paradigm can never be completely removed from the context in which it is based. Methodologically, the interpretivist paradigm favours qualitative methods, such as ethnography or case studies. However, use of quantitative methods is said by some to be permissible within this paradigm, with the aim of supporting or expanding qualitative data and deepening the understanding of the phenomena under consideration (Mackenzie & Knipe, 2006).

While studies of safety climate have not typically aligned themselves with this paradigm, some studies of safety culture have (Brooks, 2005; Szymczak, 2014; Walker, 2010), taking an anthropological or sociological stance. Supporters of this approach have suggested that conducting interpretivist research in the safety arena engenders a deeper understanding of the beliefs underlying assumptions toward safety and incidents, with the focus being on understanding, rather than evaluating, culture. Maull et al. (2001) referred to organisations as culture producing phenomena, rejecting the notion that culture could be deliberately influenced or manipulated by management (Guldenmund, 2010a).

Claimed strengths of the interpretivist approach have related to its ability to provide insight into the implicit assumptions which form the basis for norms and values that may exist within organisations. However, due to its highly contextualised focus, critics have pointed to the potential for limited generalisability, claiming that this restricts its utility in organisational research (Chatman & O'Reilly, 2016; Guldenmund, 2010b). The inability to support evidence of a relationship with organisational outcomes (Guldenmund, 2010b) or allow normative comparison (Chatman & O'Reilly, 2016) have also been cited as limiting factors of safety research conducted within the interpretive paradigm. The deep insight afforded by this approach may, however, be of value in understanding how and why norms and beliefs toward safety develop in an organisation; something that positivist researchers have yet to address (Guldenmund, 2010a).

When taken in isolation, both positivist and interpretivist approaches have significant limitations, particularly in social science research. Here, there is often a requirement to both measure and interpret findings, to ensure that information is of adequate depth, but also support generalisable conclusions to wider situations. While intuitively it would appear that safety culture might best be investigated within the interpretivist paradigm, and safety climate within the positivist paradigm, this would not be compatible with considering them as different views of the same phenomenon. From the perspective of application therefore, a combination of the strengths of these approaches, while taking cognisance of the fundamental tensions over the conceptualisation and characterisation of social phenomena, affords strong intuitive appeal. To a large degree, this reflects the perspective of the pragmatist paradigm.

Pragamatist Paradigm

Dogmatic adherence to the diametrically opposed viewpoints of the positivist and interpretivist paradigms has been held by some as partially responsible for limiting the advancement of knowledge (Howe, 1988). The pragmatic tradition is said to reject the forced choice between either a positivist or interpretivist paradigm, and allows a shift of focus toward how the combination of these paradigms may be accomplished.

The pragmatist paradigm is not committed to any single philosophy, a claimed strength being that this allows researchers using this paradigm to focus on the 'what' and 'how', as well as the 'how much' elements of the research problem (Creswell, 2003). Methodologically, pragmatism has the advantage that qualitative and quantitative methods are viewed as complementary rather than mutually exclusive (Jick, 1979) and mixed methods are commonly used (Tashakkori & Teddlie, 2003). This paradigm is not as well described or defined as either positivism or interpretivism but has the advantage of allowing researchers to mix and match research design components that offer the best chance of answering specific research questions (Johnson & Onwuegbuzie, 2004). Pragmatism uses induction (discovery of patterns), deduction (testing of hypotheses) and abduction (uncovering the best explanation for specific results) as means of advancing knowledge (Johnson & Onwuegbuzie, 2004).

Consideration of the conclusion drawn in Chapter 2 that culture and climate reflect different viewpoints of the same phenomena (Denison, 1996; Guldenmund, 2010a; Schnieder et al., 2017) appears to be well sited within the pragmatic paradigm. The position taken by this thesis in relation to safety culture and climate was that they may best be accessed using different methodologies that complement their definitions. Here safety climate was seen to refer to the surface manifestations of the underlying culture (aligned with Brondino et al., 2013), thus is likely to be amenable to quantitative measures. In contrast, insights into the underlying culture were considered best approached using deeper qualitative enquiries, which might reflect better alignment with the interpretivist paradigm. However, as the purpose of the research was to gain a holistic view and to consider both safety culture and safety climate within the FAA, adoption of either the positivist or interpretivist paradigms appeared limiting. In contrast, the pragmatic paradigm actively encouraged the combined use of both qualitative and quantitative methods in a complementary fashion (Yauch & Steudel, 2003) to address the research aims, and thus was considered the most appropriate paradigm in which to situate the current research.

Mixed Methods Research

The combination of qualitative and quantitative methods in mixed method research allows for the strengths and limitations of each to complement the other. This in turn promotes triangulation (the collection of multiple independent, compatible sources of information) which is acknowledged to improve the analytical power of research findings (Fellows & Lui, 2013). Bergman (2008) described triangulation as the use of different methods to examine a phenomenon by considering it from different viewpoints, thereby gaining a more comprehensive view than any one method alone. Although triangulation has sometimes been used as a validation technique (such as suggested by Fellows & Lui, 2013), the current research would not claim to have attempted this. In contrast, by utilising the strengths of both qualitative and quantitative methods, this research aimed to illuminate different aspects of safety culture, climate and risk decision making. Beyond triangulation, mixed method research can also be used to clarify and corroborate results from one method to another, to inform one another and expand research findings beyond that possible through use a single technique (Greene, Caracelli & Graham, 1989).

The term mixed methods tends to be applied when referring to situations when there is a qualitative phase and a quantitative phase within an overall research study and is distinct from mixed model research, which involves qualitative and quantitative approaches being mixed within the stages of research (Johnson & Onwuegbuzie, 2004). Bergman (2008) discriminated in a similar way between research designs whose purpose it was to merge parallel/concurrent qualitative and quantitative data, and those in which one method built on another. Supporters of a mixed method approach have laid claim that it allows researchers to benefit from being able to explore issues and inform the generation of hypotheses (through qualitative modes of enquiry), test these hypotheses and validate findings more formally (using quantitative methods), thus minimising the weaknesses of each approach (Johnson & Onwuegbuzie, 2004). Furthermore, mixed methods have been suggested as resulting in a richer data set and providing a higher degree of confidence in the results than may be the case with utilising any single method (Manzoor, 2016).

The premise that safety culture and climate may be measured using quantitative methods, and somehow used to infer safety behaviour, has been said to be compatible with the premise that it may be influenced by shared perceptions and shaped by the social and structural environment of the organisation, thus also amenable to characterisation using qualitative methods (Glendon & Stanton, 2000). Such an integrated approach would permit recourse to a combination of methods to support the approach to inquiry including, but not limited to, interviews, surveys, audits and document analysis (Choudry, Fang & Mohamed, 2007), with demonstrable utility in contemporary safety culture research (Brondino et al., 2013; Huang et al., 2013; Mearns et al., 2013). The current thesis was therefore conducted within the pragmatic paradigm, adopting a mixed method approach, the rationale for which is further outlined in the following section.

3.2.2 Approaches to Measuring Safety Culture and Climate

The safety culture and climate tradition refers to consideration of employee beliefs, attitudes and perceptions about how the organisation, managers and co-workers prioritise and practice safety (Mearns & Flin, 1999). Ultimately, however, the focus is not on individuals but on the shared beliefs, perceptions and practices which shape how employees interpret their work environment and behave on a daily basis. These shared safety beliefs, perceptions and practices include norms and rules for dealing with risk, safety attitudes and reflection on safety practices (Pidgeon, 1998). Therefore, although both qualitative and quantitative measures of safety culture and climate utilise individual responses, the focus is on groups and the socio-technical context in which these groups operate.

Quantitative methods of inquiry into safety climate have been dominated by the use of self-administered questionnaires, developed in the psychometric tradition (Cox & Flin, 1998; Guldenmund, 2007). Questionnaires tend to be popular because they are a quick and cost-effective way to assess an organisation's state of safety, and in some instances, have been shown to possess predictive validity in relation to safety performance lead indicators (Beus et al., 2010; Christian et al., 2009). However, while questionnaires offer insight into what safety climate may look like within an organisation, this tends to be a shallow and broad perspective (Guldenmund, 2007; O'Connor et al., 2011b) that offers little insight into why, how and in what ways the climate may reflect the culture. This deeper insight is arguably best supported through methods such as ethnographies (for example into commercial fishing, Brooks, 2005; grain processing, Walker, 2010 and hospital safety, Szymczak, 2014) and interview studies (for example in steel manufacturing, Nordloff et al., 2015; gas distribution, Blazsin & Guldenmund, 2015; and UK railways Weyman et al., 2006).

The continued use and popularity of questionnaires demonstrates their utility and longevity in applied safety research (Harvey et al., 2002; Guldenmund, 2007, 2010a). However, early quantitative safety climate research was focused toward identifying and refining a core set of dimensions that could be used to assess organisations and allow comparison both within and across sectors (Guldenmund, 2000). Arguably, this may reflect the positivist orientation of these researchers where there is a presupposition that safety climate lends itself to reduction to a generic set of constructs. However, this is at odds with more contemporary views that safety climate and the understanding of risk is inherently contextually bound (Blazsin & Guldenmund, 2015; Huang et al., 2013; Tinoco & Arnaud, 2013; Zohar, 2010).

Much of the early quantitative safety climate work can be characterised as methodologically top-down, mirroring the approach taken in other areas such as risk research aimed at deconstructing the basis of public concerns (Slovic, 1986) organisational leadership research (Tejeda, Scandura & Pillai, 2001) and team climate research (Kivimaki & Elovanio, 1999). This top-down approach was typified by researchers who determined the components/constructs of interest either through a review of the existing literature or through being directed by the organisation's management to reflect organisational priorities. This top-down approach was evident in the three military safety climate measurement tools reviewed in Chapter 2 (Section 2.6) and the HSE's Safety Climate Tool which was designed to align with the safety management principles set out in HS(G) 65 (Health & Safety Executive, 1991). Once the components of interest have been determined *a priori*, items were typically generated to reflect these components, with psychometric techniques then being applied to identify latent components of the construct. Whilst remaining exploratory, many safety climate measures developed in this way were based on the array of components that had been measured previously, relying solely on quantitative statistical techniques to inform thinking around underpinning latent variables. Effectively, the variables that emerged tended to be bound by established insights/perspectives.

Critics of this approach have suggested that it runs the risk of imposing theoretical concepts and making unreasonable assumptions of the universality of defining influences (Weyman et al., 2006; Reiman & Rollenhangen, 2011) and omitting observations which are unique to certain organisations (Yauch & Steudel, 2003). Questions have also been raised about the ecological validity of measurement tools developed using this top-down approach because it may only represent the best guesses of researchers (Cox & Flin, 1998) and may therefore be prejudiced by their preconceived biases (Schein, 1990) and reflect a bounded rationality. Here the danger is that safety climate becomes defined by what questionnaires say it is (Guldenmund, 2010a), an arising implication being that unique observations relating to an organisation or workplace context may be underplayed or go unnoticed (Yauch & Steudel, 2003).

The widespread feature of lack of stability of factor structures in safety climate studies and measures (Cox & Cox, 1991; Jeffcott et al., 2006; Reiman & Rollenhangen, 2011), combined with modest consensus over their nature (Flin et al., 2000; Guldenmund, 2000; Weigmann et al., 2004) may arguably reflect the shortcomings of top-down methodology. Importantly, these shortcomings imply that there may be added value from taking a more bottom-up, organic and contextual orientation to developing safety climate question sets and assessment tools dedicated to a defined organisation or sector (Blazsin & Guldenmund, 2015; Huang et al., 2013; Reiman & Rollenhangen, 2011; Tinoco & Arnaud, 2013; Weyman et al., 2006; Zohar, 2010). The construct of *management commitment to safety* appears the only construct germane to all safety culture and climate studies, adding further weight to the conclusion that it would be prudent to assume that local differences might be present unless it can be determined that this is not the case. This more critical perspective challenges the completeness of knowledge, understanding and assumptions of the phenomena of safety culture and climate, and how these interact.

In pursuit of contextualised measures, the intuitive benefits of using qualitative, exploratory data-driven techniques that are grounded in employee perspectives have been cited by a number of authors (Brondino et al., 2013; Cox & Flin, 1998; Huang et al., 2013; Mearns et al., 2013; Weyman et al., 2006). Proponents claimed that this allowed participants to raise issues that mattered to them (Yauch & Steudel, 2003) and, when used prior to quantitative method development, qualitative inquiry could allow determination of the most important influences on culture which merit measurement (Schein, 1990, 2010).

An example of a qualitative approach having demonstrable utility in the safety culture/climate literature was provided by Lee and Harrison (2000), who reported that an initial qualitative inquiry showed unexplored, important areas beyond that contained in their safety climate questionnaire. These authors suggested that this qualitative phase then afforded them the opportunity to add variables to capture these additional areas of interest. Thus, it is arguably important to first consider *what* is important before trying to quantify it (Brondino et al., 2013; Huang et al., 2013; Mearns et al., 2013). Failure to do so risks important influences being missed or addressed too superficially to gain sufficient insight into the pertinent issues.

Tailored safety climate measures are thought to embody the potential to tap relevant, context-dependent elements to provide a deeper understanding of the phenomena (Zohar, 2010) and avoid the pitfall of missing important factors (Cox & Cox, 1991). They also allow for more specific recommendations to be made (Huang et al., 2013) and allow determination of the impact of distinct organisational practices on task performance (Brondino et al., 2013). Each of these are advantageous for organisations seeking to use measures of safety climate to inform safety management. Furthermore, contextualised measures allow the structural and socio-technical contextual influences on safety to be considered (Jeffcott et al., 2006; Reiman & Rollenhangen, 2011). Therefore, the current research adopted an initial, qualitative exploratory approach to determine what factors were most important to employees within the sponsor organisation, prior to any attempt at quantification and development of a tailored safety climate tool.

3.2.3 Determining the Relative Salience of Safety Priorities for Improvement

Safety climate tools have typically been used to identify the impact of organisational practices on safety performance; to highlight latent vulnerabilities to safety systems and employees. However, used in this way questionnaire measures of safety climate typically treat each component as orthogonal, i.e. discrete and unrelated, with each being represented by a sub-scale on the questionnaire. Here the relative performance of each component can only be inferred from the comparison of averaged ratings from each sub-scale. When comparing the averaged ratings from the sub-scales, safety managers make some inference about the relative importance of each sub-scale - potentially focusing, for example, on constructs which show relatively negative scale ratings.

However, this approach affords only inferential conclusions to be drawn with respect to the relative importance of the constructs as each is treated as an independent entity. Such measures are therefore effectively silent with respect to the relative salience of the constructs under consideration. To compare constructs directly with each other, relative ranking techniques are more appropriate. Relative ranking methods have been used in the areas of risk perception (Ostberg, 1980), mining (Weyman et al., 2003), pest control (Barnett & Weyman, 2016), nuclear (Cromer et al., 1984) and food/consumer research areas (Gacula & Singh, 1984; van der Fels-Klerx et al., 2017) to variously capture expert, managerial and employee perspectives on the relative salience of the entities under consideration. Risk ranking takes into account the socio-cultural elements of risk assessment and might lead to a different priority set to that derived from purely technological data (van der Fels-Klerx et al., 2017). This socio-cultural element of risk assessment is the movement that gave rise to the concept of safety culture and, as such, it appears useful to consider what other methods from these associated fields may be useful to expand knowledge around safety culture and climate (Sawhney et al., 2011). This research therefore determined to explore the utility and practicality of using comparative ranking techniques to determine safety priorities, using as a starting point the tool which is currently used by the FAA to monitor influences on safety.

A desirable feature of ranking techniques is that they should permit determination of the degree of agreement between respondents, something which safety climate tools utilising ratings scales have typically been criticised for (Guldenmund, 2007). In addition, ranking of data eliminates individual differences in rating scale usage and response category numbers and labels, yet these techniques remain underused in applied work (Bockenholt, 2001). Therefore, it is argued that techniques which allow determination of the degree of consensus over priorities for safety improvement might afford additional and valuable insight beyond that offered by typical safety culture and climate approaches. However, empirical findings indicate that the choice of ranking technique can produce notable differences in the ordering of entities, dependent on how the ratings are manipulated and combined (Ali & Ronaldson, 2012; Fisher et al., 1968; Mullen, 1999; van den Fels-Klerx et al., 2017).

3.3 Rationale for the Current Approach

The research detailed in this thesis aimed to contribute to the established body of safety culture and climate knowledge through exploring, investigating and characterising variables which impact on safety and risk decision making in a military naval aviation context and exploring methods by which to determine priorities for safety improvement. This was determined to provide insight into:

1. The structural and socio-technical contextual influences on safety in a military naval aviation context,
2. The extent to which components of safety climate reflect civilian-based research findings, or represent a discrete armed-forces profile,
3. The extent to which there was a shared perspective across militarily job roles / functions and / or of sub-cultural or sub-climate profiles,
4. The extent to which safety improvement priorities can be determined through employee experiences.

The research purposively utilised a sequential mixed method design (Creswell, Plano Clark, Gutmann & Hanson, 2003) where later phases built on earlier work (Bergman, 2008; Manzoor, 2016), allowing for a more informed and holistic consideration of the research aims. This approach acknowledged that quantification of safety culture / climate was important to support safety management systems, whilst recognising the importance of the social construction of safety by employees, and the contextual factors imposed by the organisational structure and functioning. This research made use of a consolidated theoretical framework, rather than setting out to test a single model or theory (see Chapter 2). The research aimed to provide some clear direction to the FAA as to what aspects of the structural and socio-technical context (with reference to safety) were important to their employees which, if appropriately addressed, might play a role in safety management. This was achieved through four empirical studies, which were outlined in the following section.

3.3.1 Outline of empirical studies

A qualitative inquiry into military aviation safety culture as construed from the accounts of employees allowed insight into the insider perspective about how safety manifested itself in their daily work contexts (Study 1, Chapter 4). Findings from Study 1, referenced to insights from published findings allowed development of Study 2 (Chapter 5) in which an exploration of alternative techniques to provide insight into relative priorities for safety improvement (using comparative ranking methods) was undertaken. This was intended to triangulate and build on the findings from the exploratory qualitative research (Study 1) through use of novel methods to the safety culture and climate arena. The research then looked to distil these exploratory insights into the development of a tailored, quantitative safety climate measurement tool (Study 3, Chapter 6), being guided by well-established psychometric practices to investigate the underlying constructs. Following this, a further quantitative study supported the development of proto-scales which were capable of distinguishing between groups with different safety profiles (Study 4, Chapter 7).

3.4 The uniqueness of the PhD project

While there were a significant body of studies of safety culture and climate in civilian aviation organisations identified in Chapter 2, there were few published accounts of research into military aviation safety culture and climate. Chapter 1 detailed several ways in which military aviation organisations might differ from the civilian aviation sector including; the nature of tasks undertaken, dominant aircraft types, living and working conditions/situations, the purpose of the organisation, traditions/laws and views on risk taking. Given these features, it is proposed that insight from a military population may provide a unique perspective on safety culture and risk decision making (supporting conclusions by Turner & Gray, 2009). Therefore, this PhD research being sited within a military setting has the potential to contribute to the knowledge in this area.

As described in Chapter 2, the few studies of published safety culture or climate research in the military domain have typically adopted a theoretically driven, top-down approach to measure development, and have been criticised for this (O'Conner et al., 2011b). In contrast, the current research adopted a 'bottom-up' approach utilised in contemporary civilian safety culture and climate research through use of a sequentially mixed method research design (in line with recommendations made by, for example, Guldenmund, 2010a). Using multiple methods and gaining a variety of workforce perspectives is held to result in a more comprehensive view of climate and culture (Cooper, 2000). In addition, the research explored the utility of comparative approaches to provide insight into priorities for safety improvement, utilising methods that have shown merit in the risk research domain. Comparative approaches have, as yet, to receive much consideration in relation to safety culture or climate, despite their potential to provide insight beyond that offered by the traditional safety climate questionnaire approach.

The research provided deep insight for the sponsor organisation into which factors were most important in shaping and propagating a shared set of beliefs toward the level of importance of safety when compared to other organisational goals. By developing a tailored safety climate tool, as well as exploring alternative comparative techniques, the research has provided a firm grounding with which to refine a measure of safety climate for on-going monitoring within this military aviation context. Furthermore, the research afforded insight into various areas of concern for military aviation employees, providing avenues which the organisation could pursue to try and improve safety in the organisation. Through triangulation of findings, the research contained both practically useful insights for the sponsor organisation, as well as contributing to the wider academic safety culture and climate knowledge base.

Chapter 4: Exploring and Understanding Employee Attitudes to Safety Culture, Behavioural Norms and Risk Decision Making in a Military Naval Aviation Organisation (Study 1)

4.1 Introduction

4.1.1 Purpose of the Project and Rationale

Aviation has traditionally benefitted from the input of safety researchers; from technology and engineering through to social and cognitive psychology and ergonomics. The pursuit of safety improvement has prompted sustained interest in this sector. Over recent decades technological advances have significantly increased equipment reliability and the focus has moved toward understanding the 'human factor' in relation to accidents. Consequently, understanding and managing safety culture and climate within organisations has become an accepted facet of aviation safety management systems (Atak & Kingma, 2011). However, despite extensive research there remains little consensus about key salient contextual factors in this area (Guldenmund, 2007; O'Conner et al., 2011b).

A qualitative approach was initially adopted here to gain an exploratory insight into military aviation employees' perspectives of phenomena related to safety culture and risk decision making. This approach reflected an organic means of investigating safety culture (as utilised by Brondino et al., 2013; Huang et al., 2013; Mearns et al., 2013; Weyman, Clarke & Cox, 2003) and enhanced the researcher's insight and familiarity with the subject matter. Importantly it embodied the potential to provide a rich and contextually focused basis for quantification at a later stage (see Chapters 6 and 7).

4.1.2 Aim

To explore participants accounts of norms, values, attitudes and behaviour in relation to safety, particularly shared perspectives as well as structural and socio-technical elements that could be considered to characterise core influences on workplace safety culture in naval aviation.

4.1.3 Objectives

The objectives of the research were to:

1. Identify and configure an approach to engagement and elicitation with a sample of military aviation personnel that sponsors open and free discussion of the prevailing safety culture(s) and variables that impact on personnel decision making and behaviour in relation to risk.

2. Identify and articulate a set of core constructs that can be considered to characterise headline influences on military aviation workplace safety culture.

3. Compare and contrast these headline influences with published findings within the safety culture and climate domain.

4.1.4 Background

The core strength of exploratory qualitative approaches rests with their capacity to afford insight into which variables are important, and additionally elaborate on why, how, and under what circumstances. The latter is central to understanding the volition behind behaviour, underpinning sense-making, and associated rationale. It also tends to be key to informing thinking over interventions to achieve behaviour or cultural change.

Qualitative methods embody the potential to explore meaning behind experiences and how people use these to comprehend the world around them (Frost, 2011). This can be important for understanding how employees interact with, and make sense of, the socio-technical environment in which they work, including the cultural value and emphasis placed upon personal and system safety.

Qualitative approaches potentially provide a deeper understanding of employee behaviour in relation to risk that can be interactively probed and explored. Critically, not simply to determine *what* is important, but *how* and *in what ways* phenomena are salient and *how* they operate, which conventional quantitative methods traditionally cannot achieve (Caronna, 2010).

The capacity of qualitative approaches to tap into multi-dimensional insights relating to the complexities of the social world is said to be advantageous, allowing for diverse and possibly contradictory perspectives (Caronna, 2010), thereby addressing the aim of exploring the extent to which employees exhibit a shared perspective in relation to safety.

Finally, qualitative approaches are well suited for the identification of behavioural norms and collective sense making. These might, otherwise, be inaccessible to an external researcher, thus being of particular importance when considering cultural factors within organisations (Collin, 2010).

4.2 Method

4.2.1 Ethical Approval

Ethical approval to conduct the study was granted by the MODREC (reference 444/Gen13).

4.2.2 Perspective and Approach

To address the aim of the study, a qualitative approach was adopted. This was designed to deal with criticisms raised in Chapters 2 and 3 that much of the existing safety culture/climate research might impose theoretical concepts and make assumptions about the universality of defining influences. Rather, an exploratory data-driven technique, grounded in military naval aviation employee perspectives was adopted, reflecting alignment with contemporary approaches within research on civilian populations (Brondino et al., 2013; Huang et al., 2013; Mearns et al., 2013; Weyman et al., 2003).

4.2.3 Method of Elicitation

Two options for data gathering were considered, one-to-one interviews or group discussions (focus groups). Both have been widely used for exploratory research and can relatively quickly identify early indications of participants' opinions toward specific topics (Kitzinger & Barbour, 1999). Of the two, a focus group approach was chosen as it held a number of advantages above one-to-one interviews in relation to the study aim:

- One-to-one interviews are useful for exploring individual views on specific matters (Gill et al., 2008) as they allow researchers to focus on the personal perspectives, history and context (Lewis, 2003). In contrast, focus groups facilitate and encourage dialogue (Frith, 2000; Gill, Stewart, Treasure & Chadwick, 2008), allowing participants to build upon the responses of other group members, creating a ‘synergistic effect’ (Stewart & Shamdasani, 1990) which may not occur during individual interviews (Stokes & Belgin, 2006).
- Unlike one-to-one interviews, focus groups can be used to help to identify group norms, meanings and processes (Gill et al., 2008) through exploring agreement or disagreement amongst members (Kitzinger, 1995). Indeed, it is this participant interaction during focus groups that is held to illuminate shared perspectives, allowing the opportunity to display differences between participants (Lewis, 2003). Stokes and Bergin (2006) suggested that focus groups were pertinent for eliciting why a particular issue was salient, where consideration of individual interviews could restrict judgement of the level of consensus of opinion/experience across individuals. Given that Study 1 aimed to explore issues of safety culture, which is assumed to reflect a shared view, focus group discussions were considered more appropriate than one to one interviews.

- Focus groups have been criticised for their potential to allow inhibition of individuals in the face of seeming group consensus (Stokes & Bergin, 2006), however they are also held by others to be less prone to eliciting socially desirable responses (Kitzinger, 1995), which is especially important when dealing with sensitive topics that might implicate the individual (such as lack of adherence to procedures).
- Focus groups hold greater scope for verification of responses by allowing the researcher to identify whether other group members concur with discussions, or provide alternative views. By facilitating group discussion on a specific topic, focus groups are advantageous for eliciting debate over contrasts where members have different experiences of a common phenomena (Kitzinger, 1995).

The context in which the focus groups were to take place was negotiated with the FAA. To limit disruption to operational activities, timetabled breaks in human factors training sessions were identified as suitable times during volunteers to participate in data collection. Personnel that attended these training sessions were predominately drawn from the engineering and aircrew functions (these groups comprise the majority of the FAA population) although a small number of ATC personnel also attended. The research was commissioned and endorsed by the FAA's Safety Centre, which was advantageous as it allowed personnel paid time during their normal working hours to participate, thus minimising additional burden on participants.

4.2.4 Role of the researcher

The researcher was employed by the Ministry of Defence (MOD), and thus was introduced to participants as a MOD civilian, independent of the Chain of Command. Given the topics under discussion, for example rule infringement, it was important for the researcher not to be seen to 'police' safety policy to allow and encourage open conversation. Thus the researcher stressed the independent scientific research viewpoint of the study during all briefing and de-briefing. However, the effect of the position of the researcher being an employee of the MOD, as opposed to an independent consultant/student is unknown and it must be acknowledged that despite efforts to the contrary, this may have affected personnel's responses during the focus groups.

A group scenario, as compared to individual interviews, was adopted to limit the likelihood of the research being perceived as a formal interview, and more as an open discussion forum. As a civilian, the researcher was occasionally unfamiliar with some of the idiosyncrasies of the military idioms and the group scenario encouraged participants to speak between themselves. This created a more natural flow of conversation, and any queries that the researcher had about terminology could be noted and followed up after the focus group either with participants or other military safety specialists.

4.2.5 Materials

It was important to develop a set of questions that would help to stimulate discussion of topics related to the research question while allowing participants to reveal the pertinent points in an open and associative manner. It was also important to allow scope for topics that may be related, but not initially considered by the researcher, as potential topics of interest. To identify topics that would stimulate discussion, a number of sources of information were consulted to develop the focus group topic guide. These included:

1. Insights from mainstream safety culture and climate literature,

2. Findings from a FAA tool administered annually to a number of personnel related to concerns about flight safety (details of this tool can be found in Section 5.1.5 of Chapter 5),

3. Annual reports published by the RN and FAA relating to safety performance (internal RN documents which are not contained within the public domain and so could not be presented in this thesis),

4. Safety related promotional literature published by the RN and FAA, including a quarterly magazine (called 'Cockpit'), safety bulletins (internal documents), and leaflets issued by the FAA Safety Centre (examples of these publications cannot be given as they are not in the public domain).

Using these resources, a short focus group topic guide, containing headline themed topic areas and prompts was developed (see full detailed proforma in Appendix B). The final headline questions included were:

- Tell me about safety within the Fleet Air Arm.
  - Has it changed over time, and if so, how?
- What are the main barriers to safety within your workplaces?
  - What do you consider to be the main factors that mean you cannot work safely?
- What are the main contributors to accidents/incidents?
  - Can you give me an example of an accident you know about and what caused it?
- How important are safety procedures to the way you work?
- Do people bend/break the rules-can you give any examples?
  - What makes them bend/break rules?
- Is there anything more you feel I should have asked/you want to discuss with the group?

4.2.6 Pilot Study Sessions

Two pilot study sessions (involving personnel from the two main functional groups, aircrew and engineers) were conducted in order to:

1. Improve the familiarity of the researcher with the research materials,
2. Assess the appropriateness of the question set,
3. Assess the level of engagement of the personnel with the question set.

The questions contained in the proforma were well received by the two pilot groups, and several commonly used acronyms and phrases were explained to the researcher by participants. Personnel remarked that they found it interesting to discuss the topics, especially where individuals within the group had different opinions. As the question set was found to be useful for generating discussion, no changes were made and the data from the pilot study sessions were included in the data analysis phase.

4.2.7 Data Collection

Each data collection session lasted between forty-five and sixty minutes, each involving between five and eleven personnel (see Table 7) in line with existing recommendations which range between three and fourteen participants (Gill et al., 2008; Kitzinger & Barbour, 1999; Lewis, 2003; Weyman et al., 2006). In accordance with the ethical protocol, participant information sheets (see Appendix B) were emailed (along with course joining instructions) to those attending the course approximately one week prior to attendance. These personnel were fully briefed by the researcher prior to participation and signed informed consent forms (Appendix B) indicating voluntary participation. With the permission of all volunteers, the proceedings of the focus groups were audio recorded. An assistant to the main researcher took observation notes during the sessions for discussion with the researcher later. The audio files were fully transcribed by the researcher verbatim prior to analysis, with all personal identifiers removed.

4.2.8 Sample

A convenience sample of volunteers was sought from personnel attending monthly human factors training courses. Course participants were not mandated to attend the focus groups, however, time was set aside within the course to accommodate any participants who volunteered to attend. The courses provided access to a diverse sample of personnel, representing a range of ranks and specialisations (although predominately aircrew and engineers), as well as individuals drawn from a variety of training and front-line units, from units both at sea and ashore.

When considering the composition of each group, thought was given to conducting discussions with a single function at a time (e.g. engineers), or to have a mix of functions (aircrew/engineers). To encourage insight into team dynamics as well as synergies and contrasts between individuals, constructing groups with members who might normally discuss the topic under consideration on a daily basis was considered important (Kitzinger, 1995; Morgan, 1988). Aircrew and engineers have very different roles (aircrew pilot and navigate the aircraft while engineers maintain it) and hierarchical structures within the organisation (aircrew tend to comprise the senior management in a squadron) and so it was determined that the groups were more likely to discuss issues freely if separated by function.

In some groups there was a mix of ranks across the group, the aim of which was allow for similarities and differences in ideas and perceptions to be discussed by personnel within the same trade, but at different stages of employment and experience (Frith, 2000). Other groups contained participants from a single rank, the aim of which was to allow for unexplored topics to arise, in the event that some participants were reluctant to voice opinions in a mixed rank group. Due to the composition of the training course, participants were typically from a range of squadrons and locations, and so no participants were in groups with others who were in their direct Chain of Command or work team. Demographic information (age, rank, length of service and gender) was gathered to determine the characteristics of the research sample in relation to the overall population structure. Table 7 shows a breakdown of the participant sample.

Eight focus groups were conducted between December 2013 and March 2014 (Groups 1-8, Table 7). As the study was exploratory, it was considered to be important to obtain views from a wide range of personnel with varying degrees of experience of the organisation. In groups 1-8 it was noted that there was an under-representation of junior participants from the engineering trades. This cadre is tasked with the majority of the routine and operational maintenance of airframes and therefore were considered important to include within the sample. To address this potential imbalance, four additional focus groups (Groups 9-12 in Table 7) were undertaken during November and December 2014, using the same recruitment approach as for the initial eight groups, but in locations that were known to have higher proportions of junior staff. In total, 89 individuals participated in the focus groups.

Table 7.

Demographic details of focus group participants (N=89).

Group	Function	N M/F	Mean age (sd) in years	Mean length of service (sd) in years	Number by rank			
					Junior Rating	Senior Rating	Junior Officer	Senior Officer
1	Air	8/ 0	41 (6)	19 (7)			8	
2	Air	9/0	39 (5)	18 (5)			8	1
3	Air	9/0	40 (7)	17 (9)		2	6	1
4	Air	4/2	31 (8)	12 (9)			4	2
5	Eng	9/0	37 (10)	17 (12)	4	4	1	
6	Eng	6/0	32 (10)	11 (11)	2	4		
7	Eng	2/3	37 (1)	15 (4)			5	
8	Eng	5/2	35 (7)	14 (7)	2	2	3	
9	Eng	6/0	24 (3)	4 (3)	6			
10	Eng	5/0	34 (5)	13 (7)		5		
11	Eng	11/0	28 (3)	5 (3)	11			
12	Eng	7/1	39 (5)	17 (5)		8		
Total					25	25	35	4

Where Air=aircrew, Eng= Engineers, N = number of participants in group, M= male, F=female, sd = standard deviation.

4.2.9 Data Analysis

Selection of the Method for Data Analysis

Consideration was given to the relative merits of a number of alternative textual analysis techniques, referenced to the aims of the study and the research objectives. A summary of arising deliberation, culminating in the rationale for the chosen analysis method is provided below.

Discourse Analysis

Discourse analysis is underpinned by the assumption that language is a constructive social reality tool, rather than language simply reflecting reality (Coyle, 2007). Its primary focus is on examining how people use language to construct their understanding of their world(s) (Coyle, 2007). Paltridge (2012) described discourse as the social construction of reality, both shaping and being shaped by the world, thus analysis of discourse as considers the relationship between language and the social context in which it is used. Typically divided into discursive, Foucauldian and critical discursive psychology approaches, discourse analysis is said to be particularly applicable to research questions which focus on construction, rhetoric, ideology and action (Coyle, 2007). Given that the aim of the current study was to explore participant accounts of safety culture and identify over-arching themes from participant accounts, discourse analysis was determined to be too linguistically focused, and therefore incompatible with the aim.

Interpretative Phenomenological Analysis (IPA)

This method explores personal and lived experience in detail to examine how participants make sense of their world (Frost, 2011). IPA has been described as being particularly useful when focusing on a small number of homogenous participants in order to understand how people perceive significant events in their lives (Smith & Eatough, 2007). Although the method of IPA includes identification of themes from the data, the strong individual focus of the approach to data collection and analysis (Frost, 2011) was considered to be contrary to the fundamental assumption of safety culture, namely that it is a shared concept.

Content Analysis

Content analysis is arguably the most commonly used analysis method in qualitative psychology research (Carrera-Fernandez, Guardia-Olmos & Pero-Cebollero, 2014) and involves making inferences from text through using both qualitative and quantitative operations (Weber, 1990). Initially, this analysis method appeared to support the aim of the study in identification of themes from the focus group transcripts, however content analysis was ultimately considered less appropriate as it focused predominately on the frequency of concepts within a data set rather than deriving meaning from it (Biggs et al., 2013). Fruhen et al. (2013) provided an example of the use of content analysis in examining safety culture, however they integrated this with linguistic analysis due to the limitations of the deductive nature of content analysis. These authors suggested that artefacts, such as the language people use, are difficult to decipher quantitatively. Content analysis also required pre-set themes to code the data by, which did not suit the exploratory nature of the study.

Thematic Analysis

The methodical, staged process of thematic analysis was chosen to explore the transcripts in the current study as it is well suited to identifying, analysing and reporting patterns within data (Braun & Clarke, 2006). Thematic analysis presented a number of further advantages; it allowed for interpretation of the research topic (Boyatzis, 1998), while being unconstrained by a pre-existing theoretical framework (Braun & Clarke, 2006). A recognised strength of thematic analysis was its capacity to detect patterns across data; it is held to be particularly well suited to exploratory studies (Braun & Clarke, 2006). This was considered to be important for the current study, where the focus was on the work context and how it might interact with, and influence, worker safety behaviour. Thematic analysis allowed for consideration not just of what people said, but also the meaning behind what was said, and has previously shown utility in the study of safety culture (Conchie, Moon & Duncan, 2013; Lofquist, Dyson & Tronnes, 2017; Pidgeon et al., 2003; Weyman et al., 2006).

The process described by Braun and Clarke (2006) was used to inform the approach to the thematic analysis (Table 8). While it might appear that the process is undertaken step by step, in reality this was more appropriately cast as an iterative process, where previous steps and categorisations are returned to, to assess the fit of new material as it was identified from the data (Braun & Clarke, 2006). Through the analysis, the constant comparison technique (see Glaser & Strauss, 1967) proved useful; this involved the researcher taking each piece of data and comparing it with others that were similar or different throughout the data analysis phase (Thorne, 2000).

Table 8.

Process of thematic analysis (adapted from Braun & Clarke, 2006).

Stage	Description of activities
Familiarisation with the data	Transcription and repeated re-reading of the data, actively searching for themes and patterns
Generating initial codes	Organisation of data into meaningful groups, ensuring context is maintained
Searching for themes	Refocusing analysis on overarching themes encompassing the codes from the previous stage
Reviewing themes	Refinement of themes considering internal homogeneity and external heterogeneity
Defining and naming themes	Considering themes themselves and in relation to other themes, define scope and content of themes
Reporting	Reporting on the process of coding and theme development, showing systematic process

4.2.10 Initial Coding of Transcripts

The transcribed data were imported into the software program Nvivo (9), a computer assisted qualitative data analysis (CAQDAS) programme. A combination of deductive and inductive coding in line with the approach described by Fereday and Muir-Cohcrane (2006) was applied to generate initial themes. This involved identification of themes as they arose, while interpretation was guided through reference to published findings (Chapter 2). So, although the process was fundamentally inductive, there was a degree of deductive interpretation of themes. The breadth of existing research made identification of known concepts likely (e.g. Flin et al., 2000; Guldenmund, 2000) but as this military naval aviation population had yet to be the focus of safety culture research, it was expected that this also embodied the potential to identify previously unrecognised or under-articulated constructs.

The process of generating initial codes involved small sections of text being allocated with a phrase or word to describe what the text was referring to; this allowed assembly of the data into meaningful groups (Miles & Huberman, 1994). Each transcript was analysed systematically, with equal attention given to all parts (in line with Braun & Clarke, 2006). Some of these initial codes were coded and recoded in an iterative manner according to the surrounding contextual data, using constant comparison. Initial coding of the transcripts resulted in the development of 48 codes, shown in Table 9.

Table 9.

Initial codes from the transcript data (N=12).

Pressure from 'above'	Fatigue
Team and peer support important	Importance - saving lives, defence
Individual responsibility	Conflicting priorities
Military ethos-acceptance of rules and procedures	Strong identity, pride-'can do' attitude is key to FAA organisation
Need for training and experience to adapt to situations	'Them and us' regards e.g. RAF and Army
Peer review and cross checking as normal	Management and supervisors
Frustration with change in policy and procedures	Training
No, or delayed, feedback when technical changes are requested (paperwork)	Communication
High situation awareness required	Reporting/feedback
Information overload	Policy & procedures have to be there for safety
Hierarchy-trust in terms of box ticking	Working environment - hazardous by nature
Risk averseness due to 'covering one's back'	Blame / just culture
Pressure-varying demands	Equipment resource
Manpower	Operational pressure
Operational requirements big driver	Time (not operational) pressure
Reporting of incidents	Implications of making a mistake/having an accident
Managing risks as part of the job	Supervisor responsibility -PPE
Wearing of correct PPE important	Norms get taught from supervisor to junior
Not able to practice as often (pilots) so skills may fade	Can't access IT to read policies and keep up to date
Threat of working weekends if jobs are not finished	Using reporting as a tool for teaching juniors

Health and safety vs flight safety	Generic training-usefulness of manual handling training
Sign off work, now your responsibility	Aircrew need engineers to do their jobs before they can fly
Managing risks as part of the job	Supervisor responsibility
Wearing of correct PPE important	Norms get taught from supervisor to junior

As a check on coding reliability, the codes shown in

Table 9 were independently generated by the researcher and a colleague, following which the content, meaning and boundary of each of the codes was discussed between the two researchers. As during qualitative analysis pieces of data can be coded in more than one way, exploration of these potential codes was suggested to be an important aspect of the data analysis phase (Liamputtonong, 2009). This process of initial independent data coding gave the opportunity to articulate common and divergent interpretations, serving to challenge the researchers' perspectives and hone the codes and their boundaries.

4.2.11 Searching for Themes

On completion of initial coding, the process of searching for themes was undertaken (detailed in Table 8). This involved grouping together intuitively associated initial codes into categories of inter-related codes, the over-arching themes (Braun & Clarke, 2006). A core focus of this stage was on how the initial codes were similar and semantically related to each other, but also to determine their differences and boundaries. For example, some data indicated positive supervisor behaviour ("*My PO* [Petty officer] *is pretty good if I need to stop because I don't know all the process"*), while others detailed negative behaviour *("Yeah they say work safely, but they mean work fast and don't make a mistake"*). However, both related to some components of supervisor behaviour and so were grouped together in a category labelled 'Supervisor- safety priority'. This stage required the researcher to consider not just what was being said in the text, but also the meaning behind the participants' words.

Any codes that did not initially appear to be related to any others were grouped together under the category 'Other'. These codes were revisited and all codes within the 'other' category were subsequently assigned to identified categories. The identified themes from this stage were those detailed in Table 10.

Table 10.

Initial themes developed from the codes.

Theme	Aspects included in theme
Pressures	Time, supervisor and reputation, fatigue, manpower
Operational capability	Need to be safe but can't be completely safe, would never leave hanger
Team and peer support important	Pride and 'can-do', importance - saving lives, defence of the nation, them vs us (army, RAF)
Acceptance of rules and procedures	Peer review and cross checking as normal, frustrations and barriers to following procedures, constant changes to process and procedures.
Training	Need for training and experience to adapt to situations-specific vs generic training
Individual responsibility	Risk management is part of the job although at junior levels, just follow procedures. Personal culpability more so now than before (legislation). Everybody watches out for each other
Risk perception	Consequences of making a mistake/accident. Working environment hazardous by nature
Senior management	Box ticking and risk averseness
Supervisors	Role for training and mentoring, looking out for staff, checking
Communication	Feedback through publications, reporting and technical changes to publications, just vs blame culture in dealing with reports, reporting as teaching tool

4.2.12 Reviewing, Defining and Naming Themes

When reviewing themes, particular consideration was given to those which were only sparingly supported with data, or themes in which the codes were notably diverse. Patton's (1990) criteria of internal homogeneity and external heterogeneity were used to guide this stage. Here, data within each theme should fit together meaningfully, and be distinct from data in other themes. Several iterations of mind maps were used to understand the relationships between the themes in Table 10. During this process the content of each theme became increasingly consistent, allowing definition and naming of the themes. The content of each theme was summarised in a single sentence that aimed to capture the essence of the theme (named here a definition), see Table 11.

Table 11.

Themes and categories prior to inter-rater reliability testing.

Theme	Definition	Categories (sub-themes)
Policy, rules and procedures	Relates to policy, rules and procedures, including aspects of acceptance that rules are required, barriers to following procedures and situational effects on compliance and interpretation or rules.	Cultural legitimacy Barriers to compliance Interpretation of rules Situational effect on rule compliance
Pressure	Refers to any pressure, perceived or real, that is caused by the need to achieve organisational goals, including a lack of resources (human and equipment), secondary roles, or pressure caused by one function on another (aircrew/engineers).	Goal achievement: organisational pressure Interdependence of functions e.g. aircrew and engineers
Leadership and management ownership of safety	Relates to issues of how safety is managed, specifically role and effect of supervisors as well as issues relating to senior management ownership of safety under the Duty Holder construct.	Supervisory ownership of safety Senior management ownership of safety
Organisational commitment and identity	Refers to identification of self as a part of the greater organisation and pride to be identified as such, including references to safety being a part of 'who they are' as members of the FAA. Comparing themselves to other groups e.g. us vs them.	Pride Commitment
Individual responsibility: role in safety management	Includes aspects of looking out for each other and ensuring safety within the group because they are part of it.	Camaraderie and social policing
Risk perception and consequences	Relates to risks associated with work roles, function or the environment they work in, situations in which they would take risks or be risk averse and individual role as managers of risk. This also relates to consequences associated with making errors or causing an accident.	Perceived consequences Role as risk managers
Just culture, reporting and feedback	Refers to how safety communication flows around the organisation, up, down and across, this includes reporting and feedback as well as barriers to reporting. Included in this are explicit references to just culture; whether they are willing to own up to a mistake, the consequences of owning up or what happens to people after they have been found to have made an error.	Communication of reporting Barriers to reporting Sub-cultures
Training and experience	Refers to issues of training and experience, including aspects of competency and currency, erosion in training requirements and effects of this on personnel confidence.	Perceived erosion of standards and skills

4.2.13 Inter-Coder Reliability

Once the thematic framework had been developed, it was important to establish its reliability with a view to minimising bias (Daly, McDonald & Willis, 1992). Three transcripts, chosen to reflect a mix of functions and taken from the start, middle and end of the data collection phase, were coded independently by the author and an associate using the coding framework (Table 11). Cohen's kappa (k) statistic (Cohen, 1968) was calculated as an indicator of inter-rater reliability. An initial kappa of 0.62, below the acceptable threshold of 0.70 (Field, 2005) prompted a discussion regarding the definitions and boundaries of the themes amongst the author, the associate researcher and the primary thesis supervisor. Particular consideration was given to themes that displayed the lowest concordance. These themes were *individual responsibility* and *risk perception.* The interrelation and overlap between these themes was identified; personnel appeared to consider safety a personal responsibility, and looked out for colleagues because they considered them to be a 'team', due to being acutely aware of the risks associated with their work and what the consequence of behaving unsafely might be. These themes were ultimately truncated into a single theme called 'Individual and collective responsibility'. A second inter-rater reliability assessment (on a further two transcripts which were selected in a similar manner to the original three) produced a kappa of 0.72, an acceptable level of inter-rater reliability. The final thematic framework is shown in Table 12 and an indication of the spread of these themes across the twelve focus groups is shown in Table 13.

Table 12.

Final thematic framework with seven themes and twelve categories/sub-themes.

Theme	Definition	Categories (sub-themes)
Policy & procedures (T1)	Relates to policy, rules and procedures, including aspects of acceptance that rules are required, barriers to following procedures and situational effects on compliance and interpretation or rules.	Legitimacy Barriers to compliance Bureaucracy & accountability
Pressure (T2)	Refers to any pressure, perceived or real, that is caused by need to achieve organisational goals, lack of resources (human and equipment), secondary roles, or pressure caused by one function on another (aircrew/engineers).	Goal achievement: organisational pressure Interdependence of functions
Leadership & safety ownership (T3)	Relates to issues of how safety is managed, specifically role and effect of supervisors as well as issues relating to senior management ownership of safety under the Duty Holder construct.	Supervisory/line management Senior management
Individual & collective responsibility (T4)	This includes aspects of looking out for each other and ensuring safety within the group because they are part of it. This includes how this has an effect on risk perception, situations in which they would take risks or be risk averse and individual role as managers of risk. This also relates to consequences associated with making errors or causing an accident	Perceived consequences Camaraderie
Communication (T5)	Refers to how safety communication flows around the organisation, up, down and across, this includes reporting and feedback as well as barriers to reporting. Included in this are explicit references to just culture; whether they are willing to own up to a mistake, the consequences of owning up or what happens to people after they have been found to have made an error.	Reporting Just culture
Training & experience (T6)	Refers to issues of training and experience, including aspects of competency and currency, erosion in training requirements and effects of this on personnel confidence.	
Organisational commitment (T7)	Refers to identification of self as a part of the greater organisation and pride to be identified as such, including references to safety being a part of 'who they are' as members of the FAA. Comparing themselves to other groups e.g. us vs them.	Pride

Table 13.

Presence (✓) of themes (T#, taken from Table 12) in the focus group data.

	Group												
Theme	1	2	3	4	5	6	7	8	9	10	11	12	Total
T1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	12
T2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	12
T3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	12
T4	✓		✓	✓	✓			✓	✓		✓		7
T5	✓	✓	✓	✓		✓	✓		✓	✓	✓		9
T6	✓		✓	✓		✓			✓	✓			6
T7	✓	✓		✓	✓			✓		✓	✓	✓	8

Note: ✓ = theme identified in data from focus group.

4.3 Findings and Interpretation of Identified Themes

The focus groups provided a detailed insight into participants' commentaries about flight safety. The themes in Table 12 are considered to characterise headline influences on workplace safety culture and risk decision making amongst naval military aviation personnel. The following section discussed and interpreted the themes, making reference to identified phenomena in published findings. Illustrations from participant accounts were evidenced as direct quotations which are *"italicised"*, with participant demographic information contained in (parentheses) where possible.

4.3.1 Policy & Procedures

Identified in all twelve focus group discussions, the theme of policy and procedures was portrayed as playing a key role in how safety was perceived and implemented throughout the organisation. The inherently procedural nature of aviation activities was apparent amongst both aircrew *“Nearly everything that we do in aviation is very procedural”* and engineers *“Everything that we do is laid down in procedures –there is always a reference or a book you can look in if you’re unsure”*. Rules and procedures were described as being particularly key in two situations. Firstly, less experienced personnel would typically utilise checklists and printed procedure cards until they gained sufficient experience to complete tasks through skill. Secondly, the proceduralisation of tasks in emergency situations, and the repeated training of these procedures, were said to prompt almost instinctive reactions. This was held to allow personnel to deal with rapidly escalating events safely, particularly in the case of aircrew during flight. For both functions, strong organisational disapproval of a 'failure to follow procedures' was articulated as a driver for compliance; *"so* [if] *you’re knowingly stepping away from those SOPs* (standard operating procedures), *I don’t think many people, if any, would knowingly do that in this day and age"* (Engineer, senior).

These descriptions of rule/procedure use were congruent with published findings within aviation where procedures are often used as a means of organisational control to minimise risk. They do this by restricting operator behaviour to that which the organisation considers to be safe and efficient (Reason, Parker & Lawton, 1998) and by reducing ambiguity in decision making (Lawton & Parker, 2002). Employee freedom of action is restricted, while at the same time they are supported by being provided ready solutions to known problems (Weichbrodt, 2015).

There were three sub-themes identified within the theme of *policy and procedures*; *legitimacy*, *barriers to compliance* and *bureaucracy/accountability*. These sub-themes provided interesting insight into the sense making of naval aviation employees and the practicalities of procedural compliance within a large and complex military organisation.

Legitimacy

There was a notable consensus amongst participants that procedures generally represented the safest means of conducting an activity; "*If we all followed procedures, outside of mechanical failures on aircraft, human factors wouldn't happen"* (Aircrew). Participants mostly agreed that *"we have to follow the procedure, we can't go out on your own remit and start doing 'ah we feel this is the way to do it'; you have to follow policy"* (Engineer, junior). Some explanation for this was articulated, as *"many of these rules we've got in place have been brought about because of accidents happening in the past, i.e. lessons learned"* (Engineer, junior). The implementation of policy and procedures in response to recommendations from accident or incident investigations were common examples cited within the focus groups. These data were interpreted as indications that procedures were followed, not simply because they were mandated, but because the procedures were seen to have high cultural legitimacy amongst aviation employees.

These findings are congruent with published insights which hold that a high level of acceptance and adherence to safety rules is a characteristic of aviation culture (Hopkins, 2010). However, some have shown that this may vary by function/profession, where maintenance engineers have been cited as asserting the importance of individual flexibility in rule interpretation (Gill & Shergill, 2004). The view that procedures were developed through learning from accident investigations reflects learning from experience, a common aspiration in aviation. Learning from experience describes an organisation's attempt to reduce the likelihood of human errors by refining procedures and policy through using information gathered from investigations of accidents and incidents, therefore outlining routines for solutions to recurring problems (Weichbrodt, 2015).

The effect of social desirability bias cannot, however, be discounted in this finding - the organisation has displayed a notable interest in 'failure to follow procedure' in recent years and imposes sanctions (such as disciplinary actions) on non-compliance. It is possible that focus group participants may have been influenced by this knowledge, and so voiced opinions that were in line with the organisational policy. However, this concern was in part ameliorated as there were several instances where participants described examples where shortcuts could be introduced into the work process, thus suggesting that procedures and policies were not followed in all instances. These shortcuts were cited as occurring through behaviours taught to juniors by more experienced personnel, particularly engineers; *"A lot of* *the shortcuts that the younger supervisors take is because the... Chief or PO* (supervisor) *has taught them that".* Plausibly, older or more senior personnel may be more likely to have experienced times where tasks were not so highly proceduralised and had greater autonomy.

While this process of teaching and learning is likely to be key to improving junior personnel's skills, there are some potential safety implications. Senior or experienced engineers may have a better conceptual knowledge of the systems they work with as they operate at higher functional levels, which junior personnel may not have. More experienced personnel are also likely to have amassed skills and experience which junior personnel have not yet gained. The safety implications of this transfer of shortcuts were acknowledged; "*The PO knows the whole system-what shortcuts they can take and why. Whereas the guys with less experience only know the short cut, not what it's shortcutting - they forget to do one thing and it all goes wrong"* (Engineer, supervisor). It is of interest that references to shortcuts were only identified in engineering group transcripts; two potential reasons for this were hypothesised. Firstly, engineering activities often require fault analysis, which do not always follow set procedures. Secondly, aircrew checklists and flight procedures are commonly cross checked by several crew and performed in strict sequences; it may be that there are fewer opportunities to deviate from these rigid checklists.

Employee buy-in to policy and procedures is important as safety rules and barriers can only fulfil their purpose if they are being adhered to (Lawton, 1998). However, compliance typically requires the expenditure of time and effort, and within aviation accident investigations it is often concluded that non-compliance was a major contributory factor to the incident (Dahl, 2013; Dekker, 2003). Therefore, it is possible that while strong cultural acceptance of procedures is important in compliance, this may not be the sole factor influencing employee behaviour. Within the theme of *policy and procedures*, several other factors were identified as influencing non-compliance, and were grouped under the sub-theme of *barriers to compliance*.

Barriers to Compliance

Focus group participants suggested that although *"people are trying to follow procedures"*, there were situations in which compliance was deemed either impossible or difficult to achieve. These barriers were sub-divided into two main areas of discussion; (a) a lack of knowledge and (b) dislocation between the expectation of compliance and reality of everyday work. This sub-theme occurred in both aircrew and engineering focus groups.

Lack of Knowledge

Participants described frequent examples of a perceived lack of knowledge of the policy or procedures applicable in specific situations *"I don't think everybody necessarily knows exactly what procedures or what policies or regulations are necessarily applicable to what you're doing all the time"* (Engineer). This cited lack of knowledge was attributed to four main factors. Firstly, the sheer volume of policy *"Each week more policy comes out and everyone's expected to read it and take it in. It just seems to go on and on"* (Aircrew). Secondly, the disparate nature of the guidance within written documentation made it difficult to locate *"It's not all in one place, it's spread around. It's in multiple locations"*. The third factor was described as a perception of an almost constant rate of change within policy and procedures *"It's always getting amended and changes made to it"* which resulted in difficulties keeping up to date. Finally, concerns with the method of communication (often email) and poor information technology infrastructure were cited as affecting the ability to access policy and procedures, occasionally leaving personnel unaware of recent changes or updated documentation. The FAA has experienced an intense "pace of concomitant change" (Ministry of Defence, 2012, p4) to their regulation and policy in recent years, driven by changes to regulation made under the Military Aviation Authority (described in Chapter 1). This is likely to have had policy and procedure implications and may partially explain the presence of the barriers cited by military naval aviation participants' in this study.

Similar barriers have been reported previously, with a large volume of prescriptive documentation seen as characteristic of aviation (Drury & Johnson, 2013). The burden of this documentation lies in the fact that it needs to be written, verified and then updated and maintained synchronously (Drury & Johnson, 2013), a process which would arguably be made more difficult if the information is not centralised. However, this bureaucracy is important within aviation to avoid changes that may be unsound or have unintended consequences (Drury & Johnson, 2013). Similar findings have been cited amongst railway workers having difficulty in locating complex rules (Elling,1987, cited in Dahl, 2013), and miners who were not aware of procedures that existed in written documents (Laurence, 2005).

The result of this perceived inability to keep pace with current policy and procedure were highlighted by participants as unintentional violations, the likelihood of missing an important rule; *"Not knowing the rule? There's so many different rules and regulations, you going down missing the one that might be the important one, because you didn't know".* (Aircrew). This risk of unintentional violations through a lack of knowledge has been previously identified (Laurence, 2005). However, these unintentional violations have often been blamed on an inappropriate attitude or lack of motivation toward compliance, rather than knowledge of the rules that govern work (Dahl, 2013), suggesting a possible lack of understanding about the structural and organisational barriers that employees face when attempting to comply with policy and procedures. As the actual knowledge of rules and procedures was not tested in the current study it is unclear whether this is a real deficit, or a perceived one.

Dislocation Between Expectation and Reality

The second sub-division of *barriers to compliance* was broadly characterised as a claimed dislocation between the practical reality of meeting task requirements and adherence to procedures. Participants expressed the perception that "*If people followed procedures to the letter, they wouldn't get things done as quickly as everybody claims to get it done"* (Engineer, junior). Participants gave descriptions of a lack of appreciation of the extra time burden created by adhering to the policy and procedures *"A lot of this policy adds time on to jobs* [agreement] *which I don't really think is taken into account"* (Engineer) which suggested that task planning may require better consideration of the time burden. A further dislocation was highlighted through descriptions of inconsistent, inaccurate or inadequate procedures which often resulted in a difference between the way in which tasks were planned and how they were conducted. This was transparently a source of frustration, *"There were several occasions where you could actually find two bits of contradictory, um, information, so what we were doing was applying common sense"* (Engineer).

This dislocation between expectation and reality was said to partly arise from procedures being written by people not familiar with the work environment: *"They* (the people writing procedures) *don't necessarily have the competency and the experience to actually write the regulations that they've been asked to write"* (Aircrew). The increased burden of these poorly written procedures was said to manifest amongst those frontline staff tasked with actually applying the rules "*And then we are exhaustively trying to implement those and it's not surprising that actually when you are actually at the coal face, there are huge amounts of effort being exhausted by everyone"* (Engineer). These experiences were interpreted as reflecting a possible disconnect between senior policy makers and those who translate and apply policy to every-day work. Frustration and resistance might be expected from employees who perceived this process as wholly 'top-down', with little autonomy over how these policies are then enacted (Lamvik et al., 2009).

The result of this dislocation of expectation/task planning and reality was described by participants as manifesting in locally accepted ways of working, which would then assume the status of custom and practice *"A lot of it has become the norm so you don't think about it, it becomes second nature and you don't even think you are bending the rule because it's* *what you've always done*" (Engineer). These 'norms' were taught to others, over time creating a situation where "*Potentially people doing that may not know that that's something that they shouldn't be doing. Or they might, but not really consider the implications"* (Engineer). Significantly, the formation of these norms in this way was identified by personnel as a source of uncontrolled risk *"You've got routine violations, standardised norms, that kind of thing, that is an unknown risk decision"* (Engineer, supervisor).

The situation described above corroborates published findings where organisational measures to promote safety, such as personal protective equipment and procedures may be ill-fitted to field (or frontline) situations as a consequence of being devised by people with little recent exposure to frontline activities (Lamvik et al., 2009). As procedures change, and policy is updated, it is important to make sure that these can be performed as documented as the creation of 'norms' is widely held to increase the potential for error and unintended consequences (Reason, 1997). Unfortunately, these 'norms' often go undetected until an accident has occurred, and are then described as violations. Norms are generally built on the premise that past success is taken to guarantee future safety (Dekker, 2003). People in these situations may not recognise the widening gap between how things are done, and how they are formally prescribed, which has been referred to as 'practical drift' (Weichbrodt, 2015). As these local practices become shared and accepted, they may have the unintended consequence of negatively affecting the perceived purpose and importance of procedures - indeed if many procedures are seen to be inadequate or inappropriate, this may reduce the confidence in any procedures in the organisation (Drury & Johnson, 2013). To combat this, involving operational personnel in regular reappraisal of procedures has been identified as a way of assuring the applicability and usefulness of procedures (Hale & Borys, 2013).

In summary, despite an apparent employee 'buy-in' to following procedures, a variety of difficulties faced by personnel that influenced compliance with policy and procedures were identified. The impact of these barriers on personnel is described and integrated within the third sub-theme, that of *bureaucracy/accountability*.

Bureaucracy/Accountability

Despite the legitimacy afforded to procedures, there was an almost contradictory view of much of the policy with which individuals were expected to comply. A cited perception was that the organisation placed the onus on the individual for keeping up to date with policies, despite a claimed incompatibility between time available and volume of material *"If you've read them front to back it would probably take you three or four months.*" (Engineer). The requirement for employees to provide signed affirmation that they had read and understood current policy, despite this incompatibility, was interpreted by participants as the organisation transferring accountability toward operators/frontline personnel *“I feel that accountability has become much more of an issue, with ever increasing document sets of rules and regulations and more stringent procedures and signing to say you’ve read everything is potentially going to see someone in the dock, you know personally responsible.”* (Aircrew). This comment was interpreted as reflecting a concern that appeared to be generally shared across engineers and aircrew; *"I think on all levels we are aware of accountability so, the decisions that you make, you will live and die by those decisions from higher authority"* (Engineer). This accountability also manifested in signing for work processes *"Every job you do, you sign to say you’ve done that job in accordance with that paperwork”* (Engineer, junior), which participants often interpreted as ultimately placing all responsibility and accountability with the individual signing the form “*Everything is signed for, all legally binding, if something has gone wrong and somebody has cut a corner, shall we say, and not followed the procedure, then they’ve not got a leg to stand on because the paperwork is there for you to follow”* (Engineer, junior).

This incompatibility between required awareness of policy and insufficient time or resources with which to fully achieve this manifested as sponsoring a sense of (non-compliant) personal vulnerability. It appeared to engender cases where participants were aware of, or suspected, a deficiency in their own knowledge. Whilst it was not suggested that personnel should not be accountable (see later discussion of the theme *Individual & collective responsibility*), there remained an underlying concern amongst participants of inadvertent non-compliance. Here, it is suggested that the organisation might be demanding more from its members than might be possible, given the constraints placed upon them, a situation cited by Wong and Gerras (2015) as existing within the US Army. Furthermore, it has been suggested that a reliance on individual motivation and capacity to seek out new information (as is reportedly the case here), is a weak strategy for effective communication of changes (Dahl & Olsen, 2013).

Descriptions of bureaucracy/accountability in the current study have been noted in published findings where bureaucratic routines, such as requiring workers signing to say that specific rules and procedures were known and understood, are common (Dahl, 2013; Fruhen et al. 2013; Szymczak, 2014). Indeed, rules have been described as providing accountability through defining responsibility for tasks (Power, 2004) and are a key feature of bureaucracy. However, Dahl (2013) demonstrated that bureaucratic routines (i.e. getting employees to sign for work) were not sufficient to certify appropriate employee knowledge. Therefore, there appears a risk that if organisations rely on bureaucratic routines there is the possibility that they may have a false sense of security regarding the level of knowledge and compliance by employees. Indeed, there is a fine balance between the creation of sufficient processes to control safety, and excessive bureaucratization (Weichbrodt, 2015). Potential negative side effects of accountability include risk aversion (O' Hara et al., 2014), less hands-on time for supervisors to advise, lead and teach team members (Lamvik et al., 2009) and transfer in liability for the cost of harm onto the workers themselves (Dekker, 2014). Thus, arguably, organisations require a realistic understanding of the level of bureaucracy which might be inherent within their own systems, and how this might affect employee safety behaviour.

In summary, *policy and procedures* was identified as a key theme amongst military naval aviation personnel discussions around safety; while procedures were generally seen to be important, certain organisational level barriers to compliance were said to lead to increased perceptions of bureaucracy, accountability and personal vulnerability.

4.3.2 Pressure

Recounted experiences suggested that although non-compliance with safety policy and procedures would tend to be met with strong cultural, and institutional disapproval, sources of *pressure* allied to task completion were part of the everyday reality of work. This theme was identified across all twelve focus groups, and was considered to be a defining influence in shaping the culture of safety amongst military naval aviation employees. The theme of pressure was comprised of two sub-themes; firstly, organisational pressure arising from a focus on *goal achievement* and, secondly, pressure arising from an *inter-dependence of function*.

Goal Achievement

A strong influence within participant accounts on how safety was understood was the perception that the primary aim of employees was to support organisational output, known within the FAA as operational capability. However, this was also described as being balanced with ensuring high standards of flight safety. The operational capability referred to by participants can range from supporting demands in a theatre of war *“The reason we’re here is defence of the country”* (Engineer), search and rescue or humanitarian activities and peace-time training exercises to maintain levels of competent and experienced personnel *"You’ve got a flypro* (flying programme) *to meet or training to meet or even an operational programme to meet”* (Engineer). It was clear that most participants viewed the FAA as different to civilian aviation organisations *“We’re not a profit-making organisation, we’re all about operational capability”* (Engineer, supervisor). In several cases, it was observed that this separation from civilian organisations was used by participants as a justification for 'their' way of organising safety.

Supporting these organisational goals was described as fundamental *“We are in the military, we have to be operationally effective, we have to have that capability”* (Aircrew). To achieve these goals while remaining safe, the focus of discussion was on managing risks; this in itself was seen as an integral part of the military aviation role, with risk aversion seen to be a hindrance to organisational output. In balancing the sometimes-conflicting goals of operational capability and safety, personnel described themselves as risk managers, with the responsibility to determine the appropriate actions or mitigations. Consideration of risk in military, as compared to civilian, contexts has not yet received much attention in the published literature (Falconer, 2006a) and may provide a unique insight in the understanding of risk management. As compared to civilian organisations, for whom profit may create the greatest counterpoint to safety, in the FAA risk was often related to a greater ability to produce capability to support defence and humanitarian efforts. Indeed, in the military, risks may be judged acceptable in relation to the gains that are made in relation to operational capability (Turner & Tennant, 2009).

The ability to manage risks and maximise operational capability was said to be negatively affected by shortfalls in equipment; *“Money definitely seems to be a problem, cut backs or not having the equipment”* (Engineer); *"Maybe we haven’t actually got the equipment to do it, or not have some of the kit, that’s really frustrating"*(Engineer) and human resource *"There’s fewer of us as well, there just aren’t the people around”* (Aircrew). These shortfalls presented as aggravating pressure at both team and individual levels, leaving less 'slack' with which to deal with unexpected situations. To compound this issue, participants described resources as not being matched with the overall output required *“We don’t want to reduce our output at all, and the resource is getting less”* (Aircrew).

Time pressure was a cited contributor to the tension between fulfilling both safety and operational goals; *"They think they are thinking safety, but there is, I think there is just too many hidden pressures sometimes. It comes to that point where they are just too blinded by everything that needs to be done that, they’re not trying to be unsafe-but I think they are just so blinded by ‘we have got to get this finished tomorrow’ that they can’t take that step back"* (Engineer). This focus on goal achievement, described through first-hand experience, is likely to reflect an enhanced disposition to sacrifice secondary objectives in some situations. However, unlike combat situations, where worthwhile sacrifices might be acceptable (Bird, 2003), in peacetime it was acknowledged by participants that a much lower risk threshold existed.

Failure to achieve these operational goals was cast as risking reputation damage, both to the individual *"You don't want to be the one to turn round and who says we can't do it"* (Engineer, junior); or the team. Indeed, *"People feel they need to be doing stuff to get the good reports"* (Aircrew), a situation which was said to sponsor a 'can-do' attitude which was cast to be at odds with cited institutional directives to the contrary. By extension, it seemed that individual or team status might be enhanced by goal achievement in the face of adversity, which may be indicative of an underlying military culture (Bird, 2003). This was evidenced in the data where it was suggested that *"*(This may be) *indicative of how we recruit and select people and promote their careers"* (Aircrew). Comparable findings on a Swedish military sample suggest that, provided neither new pilots or senior command were observing, a certain amount of rule breaking was informally rewarded (Larsson et al., 2005). The 'can-do' culture identified here has previously been recognised (Falconer, 2006a; Hopkins, 2006). However, this phrase does not always denote negative connotations and, particularly in military organisations, when coupled with a command system which expects orders to be obeyed, this attitude may be key to the functioning of the system (Hopkins, 2006).

Trade-offs related to tension between realising both operational/production objectives and safety objectives is widely acknowledged within the safety culture/climate literature, and has been evidenced across a variety of industries (Christian et al., 2009; Mearns et al., 2004; Nordlof et al., 2015; Weyman & Clarke, 2003). Arguably, when high performance is the principle criterion for the front line, safety may be perceived as sacrificial as an effect of managerial judgement (Westrum & Adamski, 2009) with a resultant reduced attention to safety rules that impede progress (Bosak et al., 2013). Safety requires a significant reliance on finite resources (human, material and time) at a time where many sectors experience a shortfall in these resources (Mearns et al., 2004). Frazier et al. (2013) linked 'work pressure' to the degree of management concern for safety, explaining that management create the operation schedule, and so have a direct impact on safety/production conflict.

While the pressures experienced by personnel thus far were evidenced within both aircrew and engineer data, the second sub-theme of *interdependence of function* was specific to engineering participant discussions.

Interdependence of Function

Engineering personnel cited numerous experiences where they felt pressured specifically by aircrew, for example *"When I was onboard we had pilots coming out to do walk-rounds before we had finished our servicing, because they had to make their flypro* (flying programme)" (Engineer, junior). This description was interpreted by the researcher to relate to the interdependence between engineering and aircrew functions. For aircrew to fulfil their function (fly the aircraft), the engineers must first successfully complete their task (make the aircraft ready to fly). Furthermore, the engineers performing the servicing of the aircraft are typically junior (rating) engineers, whilst aircrew are typically of a higher rank (officers). In this military system, therefore, this is the equivalent of senior management placing implicit pressure on junior staff by walking around their workplace and questioning them about progress.

Some engineers did acknowledge that aircrew were not typically unreasonable "*All we needed to do was say 'can you just let us finish our servicing please Sir?' And that would have probably have been fine. But as it was, everybody got all headless chickens and, running around and trying to get it all done."* (Engineer, junior). Thus, it would appear that this pressure may partially arise from within the engineers themselves, with some degree of assumption about the level of urgency implied by aircrew actions. Given that they will depend on the serviceability of the aircraft in flight, seems unlikely that the aircrew would deliberately pressure the engineers into a position where safety may be compromised, however they may be unaware of the implicit pressure caused by their presence on junior personnel. This sub-theme of *interdependence of function* has not been explicitly identified within the safety culture and climate literature. However, a similarity was observed in Baker's (1998) safety culture survey for aviation maintainers in which a factor referred to as 'communication/functional relationships' contained questions regarding the level at which maintainers were shielded from external pressures when completing a task.

In summary, a variety of sources of pressure were described by participants as affecting safety behaviour. Several were common to aircrew and engineers, while one (*interdependence of function*) was specific to engineering participants.

4.3.3 Leadership and Safety Ownership

The theme of leadership and safety ownership related to employee perceptions of the relationship between management/leadership and safety within the organisation. This theme was presented in participant accounts across all twelve focus groups, with a distinct separation between the characterisation of supervisory and senior management levels.

Supervisory/line management

Supervisors/line managers were presented as most influential in day-to-day business, being directly responsible for the safety of their teams and their output. Supervisors tended to be cast as key role models, passing knowledge, safety behaviours and shaping the culture of future generations of supervisors *“The different techniques that people have to supervise, and the way they’ve been taught, and the procedures that they follow, are passed down to the lads.”* (Engineer, supervisor). The potential for poor safety behaviours to be passed down was acknowledged; *“If you get someone who says the procedures are not important then if you get into a trend of doing that then when those lads become supervisors then they will say that that’s the way they’ve always done it.”* (Engineer). Thus, it would appear that participants in this organisation take many of their cues regarding safe behaviour from their supervisors/line managers. Thus, these positions are likely to be key roles within the safety management system for both teaching and monitoring of appropriate safety behaviour.

Other supervisory responsibilities ranged from watching out for more junior personnel, *"Periodically* [check] *to make sure that he’s safe throughout it"* (Engineer, supervisor), to regulating compliance with protective equipment and work procedures, to acting as a role model. Much of the strength of supervisor effect on the focus group participants was attributed to the small organisational distance between frontline personnel and their supervisors *“On the shop floor you’re like the first line of defence to make sure nothing goes wrong, people rely on you to make sure its supervised and the job is done properly because you're middle management and higher management they are in offices so they need you to do your job properly"* (Engineer, supervisor). The fact that senior and junior aircrew often flew aircraft together was cited as a possible reason for the strong influence of seniors/supervisors on junior aircrew.

Underpinning the discussions was a belief that confidence and trust in supervisors/line management were key enablers for raising safety issues or concerns; *“When your* (managers) *are like ‘fine yeah crack on’ you know - and they don’t make an issue out of it, that’s when you feel more comfortable being able to speak up”* (Aircrew, junior). The degree to which participants were likely to admit an error was linked to how they had observed their supervisors react to similar situations in the past, particularly if it was felt that they had acted fairly or not. Unfortunately, participants described the risk of these supervisory functions being hindered by increasing bureaucracy *“Well that stops you being on the shop floor supervising as much because you’re doing paperwork, you’re in the office”* (Engineer, supervisor).

The descriptions of reduced hands-on supervision described in the current study was somewhat reflective of other industries such as oil and gas, where a 'drift' in management practices saw managers spending increasing amounts of time on planning, handling procedures, reports and documents and less time on hands on work (Lamvik et al., 2009).

Work overload and production pressure have also been cited as hindering supervisor safety leadership (Conchie et al., 2013). The descriptions of supervisor effects on employee behaviour in this study corroborate previous findings in which role model behaviour and subsequent reinforcing behaviour was attributed to monitoring and control by supervisors (Flin & Yule, 2004; Thompson, Hilton & Witt, 1998).

Senior Management

In contrast to the lengthy and detailed discussions surrounding the importance of supervisors on employee safety, articulated first-hand knowledge of senior management ownership of safety was limited. These discussions appeared to be cast more as general impressions, which is likely to reflect the fact that few of the focus group participants held senior management positions (see Table 7). This is, perhaps, similar to many large, hierarchical organisations and so it was of interest to explore the methods by which participants interpreted senior management commitment to safety if not by first hand observation. Currently, little is known about how senior management actually influence safety in practice, despite being acknowledged as integral to setting the tone and tempo of activities (Flin et al., 2000).

Participants appeared to have mixed perceptions as to the role and motivation of senior management in relation to safety. Some described senior management as having a good ownership of safety, observed through the resources dedicated to training, safety promotion and accident/near miss reporting. Others, however expressed disillusionment as to the motivation behind senior management commitment to safety. Impressions of senior management using safety as a *"box ticking"* exercise and becoming increasingly focused on the minutiae surrounding adverse incidents (rather than what the participants saw as the 'real' issues) were described as placing unwarranted pressure on frontline/supervisory staff. Although this might be seen as senior management becoming more aware of safety concerns, it was in this case interpreted by participants as management wanting to ensure that their 'backs were covered' and fostering risk averseness *"The risk averse nature of the people higher up the echelons, all the way up and in between, they are not taking that risk on"* (Aircrew).

Similar observations to those reported here have been made in other large, bureaucratic organisations (Cabrera et al., 1997; Mearns et al., 2003) which may reflect the lack of transparency with which they operate. It is often difficult to see the reasoning behind decisions made at senior levels from frontline roles, and this may lead to assumptions being made about senior management motivations. The hierarchical structure might affect the communication of these policies, such that the purpose of the policies may not 'filter' down to the frontline (Yule et al., 2007). Tappura et al. (2017) suggested that the key role of senior management in relation to safety is through ensuring the correct organisational policies are in place, operating as they should and providing sufficient resources to enact these policies.

In summary, although the influence of managers and supervisors was described to be key to safety, much of this was attributed to supervisors/line managers, rather than senior managers. However, the lack of senior management participants within the focus groups may have limited the insight into this sub-population.

4.3.4 Individual & Collective Responsibility

The fourth theme was labelled as *individual and collective responsibility*, and was comprised of the sub-themes of *perceived consequences* and *camaraderie*. This theme was identified in seven of the twelve focus groups, both engineering and aircrew, although only in two of four junior engineering focus groups. Participants presented a high intrinsically motivated view of their individual responsibility for safety, in relation to personal safety, the safety of colleagues "*We're our brother's keeper and look out for each other"* (Aircrew), and the public.

Perceived Consequences

The high levels of personal responsibility inferred from employee experiences may stem from an appreciation of the severe consequences of military aviation that was evidenced in the data *"These things are multi-million pound aircraft, and they are dangerous when they go wrong"* (Engineer). Military aviation was portrayed by participants as inherently involving risk, which could not be completely eradicated, but rather managed appropriately *"When those risks are made, predominately they are made with due risk assessment"* (Engineer). This risk assessment was described as operating at macro (organisational) and micro (local risk assessments and risk-based decision making) levels. The risk of aviation activities was differentiated by the participants according to activity performed; flying was seen to be the activity associated with the highest consequence (to aircrew and the public). However, it was also acknowledged that work in the hanger (i.e. aircraft maintenance tasks) held certain risks as well, although potentially of a different type; lower severity but increased frequency.

These findings corroborate those reported by Turner and Tennant (2009) who found that risks associated with military activities would not be acceptable in civilian companies, but were what allowed the military to achieve its objectives. Thomson (2015) suggested that in military environments there was an expectation of risk because of the nature of the organisation, yet there may be a political/public perception that standards of safety should still be in some way comparable to civil standards.

Camaraderie

Separate from the hazardous nature of aviation was the second sub-theme that appeared to underpin how participants experienced individual responsibility for safety. Here, small teams "*On a flight you're in a small group"* (Engineer) and familiarity with others *"You work with the same people day in day out*" (Engineer) were described as being drivers for being mindful of one other's safety as well as one's own "*You've got to kind of look after each other as well*". This was interpreted by the researcher as a feeling of camaraderie, with groups of individuals taking on a moral responsibility for each other's safety *"I think you've got to be observant and look after each other as well, being switched on and thinking well someone could get themselves hurt".* The particular responsibility of more senior or experienced ranks toward their juniors was apparent through cited examples "*To an extent you are responsible for yourself but you might have a lad who's a week 1 or week 2 trainee and it's all new to him and they're keen so they don't look around"* (Engineer, supervisor).

Unsurprisingly, this camaraderie has been identified in other military samples, and has been referred to as 'fictive kinship', whereby groups of military personnel display close relationships that are created by shared experiences (Woodward & Jenkins, 2011). Camaraderie is said to be influenced by factors such as team size, member similarities, external competition and group success (Mitropoulos & Memarian, 2012); that it can create a sense of "belonging" in military personnel (Kirke, 2009; Veestraeten, Kyndt & Dochy, 2014); that it is integral to their functioning and that it reflects high group cohesion. It must be noted here that although the intrinsic motivation to work safely was apparent within the theme of *individual and collective responsibility*, this was not the sole factor related to this behaviour. The extrinsic motivation of legal responsibility and culpability, which was seen to operate predominately at the individual level, was keenly felt by many participants and was previously discussed within the sub-theme of *bureaucracy/accountability*.

In summary, naval military aviation participants cited *individual and collective responsibility* as a key motivator for safety. The high consequences associated with aviation accidents, and high levels of camaraderie, which is typical of military organisations, appeared to foster this sense of responsibility.

4.3.5 Communication

The fifth headline influence on participant's perceptions of safety was communication within the organisation and was identified in nine group discussions (all four aircrew and five engineering groups). Two sub-themes were identified within communication, *reporting* and *just culture*. Top-down communication was described to exist in a variety of forms, including electronic communication (email), safety publications (quarterly and monthly), and through feedback from safety committees (held at unit level). However, while safety publications were perceived to be effective, there was some criticism of communication that relied on the hierarchical management structure "*At squadron level your committee, especially in my experience, doesn't pass on anything they've discussed down the chain*". A more dominant aspect of this theme related to bottom-up lines of communication, through reporting of accidents/incidents/near misses.

Reporting

The FAA has a number of different methods for reporting, ranging from the formal air safety management system (an online tool for collating and managing safety reports), through to reporting logs (which are books in which people can write safety concerns that are then reviewed by safety representatives). An anonymous reporting mechanism is also available.

Discussions between participants indicated that there was generally a positive, shared acceptance of the requirement to report accidents, incidents and near-misses *"I think there always has been to quite a healthy degree, as far as my time being in, certainly from this, in talking about, discussing, reporting"* (Aircrew). It was notable, however that these discussions were mostly held between participants of supervisory levels and above, with little detail appearing in focus group data from most junior personnel groups. The reporting system was generally praised *"We've got new reporting systems now and that resulted in a far more widespread knowledge of what's gone on"* (Engineer), although some reservations from experienced individuals suggested that this system was being used to report events which were not safety related.

While reporting of incidents, accidents and near-misses is made mandatory within the FAA, it is important that personnel believe in, and trust, the reporting process. In this study, the acceptance of reporting as necessary appeared to be due partly to its perceived importance for facilitating learning *"Other people's mistakes are really good learning tools"* (Engineer) and *"Every single one of them is reviewed for safety implications, making sure that action is taken from every occurrence"* (Aircrew). Additionally, for some, the requirement to report near-misses and errors went beyond an organisationally driven requirement, to fall within personal integrity *"Integrity is a massive part of our job anyway, if you mess up you've got to put your hand up. You've got to at the end of the day."* (Aircrew).

The importance of communication of safety related information throughout an organisation is often cited as being integral to instilling a good safety culture (Diaz-Cabrera et al., 2007; Glendon & Litherland, 2001; Mearns et al., 2003) as it encourages trust between employees and management to identify and deal with hazards (Block, Sabin & Patankar, 2007). In this way, it is also practically necessary for identification of factors that may be embedded in the work environment or socio-technical systems. A good rate of quality incident reporting has often been used as an indicator of a well-functioning safety system (Fung et al., 2005).

Although there was a general acceptance of the importance of reporting, a number of barriers were articulated, which enabled a contextualised understanding of reasons behind why participants might be less likely to report. The first of these was a notable concern over personal reputation "*There's just still the stigma of being labelled. You know, people start talking about it"*. There was also an expressed reserve toward reporting for fear of being seen as incompetent or as a trouble-causer *"There's very, very few people still within, I'll say in all walks of life, that want to stick their heads above the parapet"* (Engineer).

These findings presented an interesting dichotomy where participants appeared to accept the need for reporting, however still appeared to believe that there may be negative impacts to themselves if they did report. Similar findings reported by Nordlof et al. (2015) showed that employees acknowledged reporting as important, yet admitted often avoiding it due to the embarrassment of admitting one's own mistake. Furthermore, findings from research in the UK railways suggests that a strong emphasis on reporting by senior management may not be enough to counter perceptions of blame and culpability associated with reporting by those on the frontline (Weyman et al., 2006).

Just Culture

The second sub-theme of communication was *just culture*, a term which is actively promoted in the organisation, and has thus become common terminology within participant discourse. A just culture is said to encourage healthy occurrence reporting by treating individuals in a fair, consistent manner and ensuring sanctions are appropriate (Ministry of Defence, 2009). Perceptions of the application of a just culture amongst the sample of personnel were mixed, particularly more so than many of the other sub-themes. Some perceived it to be functioning, as shown in the excerpts below:

"I think there's a real understanding and feeling that actually if they, they might be very junior but if they do see something that is not right, rather than just to go along with it and say 'oh well it's probably be alright, there is a good understanding that anybody can stick your mitt up and say actually something is not right, stop and that you won't get a hard time for doing that" (Aircrew);

"We've got a robust system to highlight safety issues. We've got a just culture, not just a corporate term, we use it on a daily basis and tell the lads that if they make a mistake then that's ok and they appreciate that" (Engineer, senior).

However, others relayed scepticism in the application of the concept;

"There is certainly a fear, I mean if you talk to the lads (junior engineers) *there is a fear, well a fear of being done for doing something wrong, you know"* (Engineer, supervisor).

Broadly, a difference in perception was identified between the aircrew and engineer functions *"But the maintainers-almost to a man- said yeah there is definitely a delta between what the aircrew are prepared to do, put their hands up, versus what we are prepared to do as maintainers"* (Aircrew). One engineer supervisor described this further *"When you get down to the lower levels of engineering I don't think there is a perceived just culture on the shop floor for the engineers at all."* The participant accounts appeared to show that aircrew had relatively high levels of confidence and trust in their supervisors and management while junior engineers were interpreted as having less confidence. Supervisors have been shown to play a key role in promoting workplace safety by affecting the level of fairness perceived by employees (Thompson, Hilton & Witt, 1998).

Some of the noted differences in opinion on just culture were attributed to the formal structure of each function, with aircrew management structures tending to be 'flat', with a relatively shallow hierarchy gradient *"I think also in aircrew it's not the traditional military pyramid, it's very top heavy and so you've got more of your peers judging you"* (Aircrew). In contrast the engineering management structure has a much more defined difference between senior and junior ranks. Furthermore, the most senior personnel in the units tend to be aircrew, and so it could be that a lack of understanding of the engineering function might result in a different view of fault/responsibility when an incident involves an engineer, as compared to when it involves aircrew personnel.

4.3.6 Training & Experience

The sixth identified theme related to participant's perceptions of training offered by the organisation, and the experience gained on the job, and how this impacted on safety. This theme was only identified in data from a sub-set of six groups, and did not contain any sub-themes.

Specific discussions amongst participants regarding training mainly surrounded mandatory Health and Safety (H&S) training, rather than aviation specific training. Participants appeared to view this type of training particularly cynically, which appeared to be related to the generic nature of the training and how it was delivered. This included aspects such as display screen equipment and manual materials handling training, delivered through e-training and online tests. These were referred to predominately as box ticking exercises and of lesser importance than trade-specific or human factors training when related to flight safety.

As an associated, but separate, focus data from aircrew groups revealed further insight into their concerns about experience and perceived erosion of skill over time. Aircrew participants described a perceived risk averseness at senior command levels which was seen to impact on their ability to train effectively and thus gain experience *"I think there is a fear of blame and I think the knock-on effect of this is that people don't fly the aircraft to its full ability, to expand the flight envelope"* (Aircrew). These individuals cited resultant negative effects on their confidence as related to their perceived lack of experience. They appeared to fear that an inability to train in realistic scenarios might negatively impact their performance, should they encounter such situations in the future.

The importance of training on safety has been identified within aviation studies (see, for example, O'Conner et al., 2011b), while in other meta-analytic studies it has generally been implied under the overall theme of 'safety systems' (Flin et al., 2000; Guldenmund, 2000). Whilst the study did not measure either training or experience levels, the perception of aircrew that their skills were being eroded may be coloured by longer serving aircrew who are likely to have experienced different methods of training to those now employed. Arguably, understanding and acceptance of risk has probably changed over time, and it is likely that training methods that were acceptable in the past are no longer considered appropriate. The anecdotes and stories passed down between senior and junior aircrew may reflect a perception of 'the good old days'. Furthermore, although participants interpreted what they saw as senior management risk averseness, this interpretation may only be based on a partial understanding of the intentions of senior managers, who may have to prioritise certain activities above others.

4.3.7 Organisational Commitment

The final theme identified in the focus group data was one that appeared to be a common thread which was loosely related to several of the themes already mentioned. This related to how participants appeared to identify themselves as part of a group, with regards to their safety beliefs and practices and was labelled as *organisational commitment*. This theme was identified in eight of the twelve focus groups, across both engineering and aircrew. This organisational commitment appeared to typically be conceptualised at the level of the FAA rather than the level of the overall RN. This perhaps reflects how different the employees of the FAA consider it to be to the rest of the RN. Numerous references were made as to the superior safety performance of the FAA *"We always tend to think we're better than everyone else"* (Aircrew) when compared to civilian aviation organisations and military aviation counterparts from other Services (i.e. RAF or Army). Participants appeared to take pride in this reputation, and not wanting to endanger it though unsafe activity *"Safety reputation of the* [organisation] *is all important-we think we're reasonably safe but not complacent"* (Aircrew). This commitment to the organisation was interpreted as underlying the importance placed on flight safety, not as something that had to be complied with, but something that formed the basis for all activities within the organisation. This was reflected in several representative comments:

> *"So, I don't think it sits in a list of priorities, I find it's just, it's just something that you are always aware of. I find it's in everything you do. Flight safety has to come within all uh considerations basically"* (Aircrew);

> *"I think that's [*the importance of flight safety] *very real, within the* [organisation]*, you know we are brought up from day one to understand what that means to us and how we should, you know, cherish that, it's a good thing and so on"* (Engineer).

This shared belief was described as being taught to personnel from the start of their careers, such that it became entrenched in all aspects of work life. This was also described as being internalised, such that their personal pride in doing a job well, and safely, was explicitly related to supporting the positive overall safety reputation *"There's a pride to it, you know and you want to be able to go and do your job to the best of your ability"*.

In summary, the seven themes identified across the twelve focus groups were, to a large degree, supported by published findings, although certain contrasts with the existing literature have been described. The following section integrated these findings into a broader discussion, considering the implications of the findings to the FAA specifically.

4.4 Discussion

The current study applied an embedded, context-focused analysis of employee accounts to explore influences on safety culture in the context of military aviation. This reflected alignment with the growing body of contemporary studies of organisational safety culture which have advocated the need to focus on, and gain insight into, context specific components prior to attempts at quantification (Brondino et al., 2013; Huang et al., 2013; Mearns et al., 2013). The process of identifying those constructs that employees felt influenced safety involved conducting focus groups (N=12 groups) with military naval aviation participants. Seven themes were identified; *policy & procedures*, *pressure*, *leadership & safety ownership*, *individual & collective responsibility*, *communication*, *training & experience* and *organisational commitment.* Globally, safety was presented as a deeply embedded, integral component of the participants' world view; safety issues were ascribed high status and importance within employee discourse and orientation to their work. Broadly, themes were distributed across aircrew and engineering focus groups, indicating a degree of agreement across the functions. However, the emphasis of each theme was sometimes slightly different between aircrew and engineers, which will further be discussed here.

4.4.1 Policy & Procedures

From the participants' descriptions, it was clear that there was a high degree of acceptance of, and compliance with, safety policies and procedures, to an extent that presented as greater than in most other employment sectors beyond aviation. Both aircrew and engineers emphasised consistent use of SOPs through their job (similar to findings from Patankar, 2003) and saw compliance with these as key to determining safety behaviour (aligned with findings from Lawton, 1998). However, others have suggested that it is not simply enough to have compliance, but that voluntary safety participation is also important (Dahl & Olsen, 2013), a factor not explicitly identified in the current study.

The findings detailed in Section 4.3.1 identified a number of barriers to compliance with policy and procedures. These are particularly noteworthy, given that an important component of managing safety has been identified as monitoring the gap between procedures and practice (Dekker, 2003). It is noteworthy that much of the existing research in this area focuses on the individual, their safety motivation and attitudes toward compliance, rather than knowledge of the rules that govern work (Dahl, 2013). However, the current findings would suggest that military naval aviation personnel were motivated to comply with rules, but that organisational barriers were a strong disincentive, acknowledging the potential for self-serving bias here. Non-compliance can quickly lead to situations where even vital safety procedures are no longer viewed as essential (INSAG, 2002), thus it is important to identify where procedures need to be altered, removed or reiterated (Hale & Borys, 2013) to address disincentives to compliance.

Headline barriers to compliance in this study included claims that some procedures were not fit for purpose, perhaps due to a lack of insight on the part of their architects into the realities of the front-line context. Effective procedures on paper have been shown not to necessarily translate into procedures that are easily understood and applied by those who would use them (Blazsin & Guldenmund, 2015; INSAG, 2002). To combat this, involving operational personnel in devising safe systems of work is widely regarded as key to developing practicable and workable procedures (Hale & Borys, 2013)

The perception that policy and procedures were constantly changing and increasing in volume has been acknowledged to result from the temptation within organisations to rely on increased expansion of procedural documents in the wake of accident investigations (Hale & Borys, 2013; Hopkins, 2010), a situation said to be particularly common in the UK (Dekker, 2014). Questions have been raised as to whether increased regulation and proceduralisation always improve safety (Bieder & Bourrier, 2013; Hallowell & Gambaste, 2009) or whether they just add to bureaucracy. Power (2004) labelled this process the 'bureaucratisation' of the safety agenda and warned that the intensified focus on auditable trails of documentation can create a vicious circle whereby multiplication of rules leads to increased dependence on the rules as a means of avoiding responsibility, and increased time spent on auditing the functioning of this process. This has the potential to lead to a misplaced focus on process, rather than on controlling or dealing with hazards. Arguably these findings might indicate that it is important for the FAA management to ensure that creation of, and compliance with, policy and procedures is safety, rather than process, focused.

A focus on proceduralisation has also been criticised for incentivising a preoccupation with numbers/targets and strict compliance, where a wider focus on equipment design, leadership styles or inadequate work organisation may be more appropriate (Grote & Weichbrodt, 2013). Therefore, it is arguably important at the organisational level to ensure that new procedures are not the default action after incidents occur, but that all possible mitigations are also explored (such as better design or changes to work processes).

Although many of the cited experiences in relation to policy and procedures were common to aircrew and engineers, the descriptions of informal teaching of non-standard shortcut behaviour was observed to arise only in data from the engineering groups. While it is not suggested that senior aircrew never teach junior aircrew shortcuts, the findings here are comparable to those detailed by Van Avermaete & Hakkeling-Mesland (2001). These authors reported that aviation maintenance personnel tended to see themselves as personally responsible for the airworthiness of the aircraft and cited the importance of using their experience and skill to ensure this, even if it required deviation from procedures. Interestingly, in contrast, managers within that organisation viewed the maintainer's primary role as following formal procedures in order to maintain safety (Van Avermaete & Hakkeling-Mesland, 2001).

4.4.2 Pressure

A notable feature in the current study was the juxtaposition of the high status of safety with a variety of competing demands, pressures and barriers with some (perceived to be lower risk activities) at risk of being treated as sacrificial to meet operational demands. However, a strong emphasis on operational safety, and safety of others, while at the same time being prepared to increase personal exposure to risk likely reflects the strength of shared high-value purpose that has been found in other cohesive groups working under extreme conditions (such as the emergency services, O'Hara et al., 2014).

While not necessarily seen as mutually exclusive, the ability to work as safely and as productively as possible were observed to engender some degree of tension, which may reflect a safety-production incompatibility (McLain & Jarrell, 2007). This is a common thread in many safety culture assessments, often assessed under the label of 'work pressure' (Flin et al., 2000). When high performance is the principle criterion for the front line, policy may get violated as an effect of managerial judgement (Westrum & Adamski, 2009). In the military aviation context, this was characterised as maintaining operational capability in the face of both personnel and material resource shortfalls and was said to sponsor a ‘can-do’ attitude. Although reduced spending budgets and problems with retention and recruitment of experienced personnel is unlikely to lessen the pressure felt by military aviation personnel, from an organisational perspective it is important to consider existing evidence which shows that less conflict between safety and production goals increases safe work behaviour (McLain & Jarrell, 2007) and that work pressure has been correlated with risk taking and accidents (Weyman, Clarke & Cox, 2003). This is thought to occur as workers are incentivised to take short cuts (O'Dea et al., 2010) which places them closer to the boundaries of safe performance (Mitropoulos & Cupido, 2009). Addressing these key areas that are seen by personnel as creating pressure might arguably be seen as an important consideration for the FAA management in terms of areas to consider allocating resource to.

4.4.3 Leadership & Safety Ownership

Management ownership of safety is the only component over which there has been universal agreement within safety climate/culture research (Flin et al., 2000). The primacy of this factor is supported by indications of predictive relationships with safety behaviours (Cheyne et al., 1998; Christian et al., 2009) and is suggested to be a key component of safety initiatives (Brown, Willis & Prussia, 2000; Yule, Flin & Murdy, 2007; Zohar, 1980). Indeed, participative management has been shown to increase workgroup compliance (Mearns et al., 1997; Simard & Marchand, 1997) and result in fewer injuries (Michael, Guo, Widenbeck & Ray, 2006). Other key identified supervisory behaviours are supportive leadership styles, the willingness to initiate safety discussions and give positive feedback in terms of safety behaviour (Niskanen, 1994; Simard & Marchand, 1994). The identification of leadership and safety ownership in the current study showed consistency with established insights from the area of safety culture/climate.

Scepticism amongst participants in this study appeared to be levelled at senior management who were not seen to "walk the walk" (i.e. follow through on their views that safety is the most important factor by increasing resources or reducing demands where safety was potentially compromised by these), corroborating findings reported by Biggs et al. (2013). Arguably these frustrations may be further exacerbated if senior managers are perceived not to have experienced the pressures faced by frontline personnel and therefore don't 'understand' the reality of trade-offs in everyday situations. These findings related to negative perceptions of senior management in the current study must, however, be interpreted in light of the fact that they may, in part, reflect the lack of direct observation of senior managers' behaviour. In the absence of actual observation of behaviour or knowledge of decision-making processes, affective processes are likely to dominate how personnel will form perceptions of senior management (Guldenmund, 2010b). Therefore, employees may tend to use other indicators from the workplace in an inferential manner (such as where resources are being spent, or stories from peers/supervisors) to develop a view on what is important to senior management (Cabrera et al., 1997; Mearns et al., 2003). This has the potential for misunderstanding/misinterpretation of the true intentions of senior management, and so should be interpreted with caution.

There were few senior officers within the sample, partially due to the sampling strategy, but also due to the difficulty with accessing these personnel for research. Other researchers experienced similar difficulties; Fruhen et al. (2013) suggested that the limited amount of research on senior management participants in safety studies may reflect difficulty of access, or plausibly interest in, and commitment to, the subject matter. Zohar and Luria (2005) cautioned that the views of safety at the top of on organisation can vary considerably from those at other management levels, and this is an acknowledged limitation of the current study. Interestingly, Fruhen et al (2013) showed a self-serving bias in senior management, where individuals were seen to overestimate their influence over safety outcomes. This self-serving bias is likely to be a consideration, regardless of what level is investigated; it is particularly likely that frontline individuals place blame on management, while management are likely to blame frontline individuals for safety issues. A mixture of both of these is most likely to reflect reality within the organisation.

4.4.4 Individual & Collective Responsibility

The participants in the current study presented a high, intrinsically motivated view of their individual responsibility for safety. That is, they felt that it was their responsibility to look after themselves and their colleagues. This was partly attributed to the high levels of camaraderie which has been observed in other military samples (Woodward & Jenkins, 2011), as personnel arguably may be more keenly aware of the safety of those they have an affinity with/care about. Group cohesion has been positively linked to safety climate (Kelly et al., 2015), safety climate strength (Luria, 2008), compliance and normative behaviour (Simard & Marchand, 1997) as well as feelings of personal responsibility and ownership of safety (Clarke 2010; Geller et al., 1996). The trust between team members in small teams, as described in this study, is particularly valued in the military context because individuals often must rely on the performance of others in a wide variety of high risk, high tempo, physically and mentally demanding situations (Guzzo & Dickson, 1996).

Although camaraderie was presented positively amongst participants in this study, high group cohesion and camaraderie have also been shown to negatively impact on safety. Peer pressure, coupled with a 'can-do' culture may override an individual's willingness to admit to being unable to complete a task by making individuals feel less able to speak up against group 'norms' (Falconer, 2006a). Thraldsen et al. (2010) provided an interesting parallel to the current study's population, researching oil and gas employees who often worked on the same isolated platform for a long period, with the same crew. These authors suggested that although trust in workmates had a positive function and effect on safety performance, it could also lead to blind rule following, too much trust, a lack of independent checking and relying on the effective performance of others. Given the focus group setting of the current study, it might be argued that participants might be less likely to raise any concerns or examples of negative impacts of their peer group on safety, and this may be a limitation of the current approach.

4.4.5 Communication

While the importance of communication of safety issues through reporting was discussed by both aircrew and engineers, the underpinning concept of just culture appeared to show differences between aircrew and engineer experiences. Just culture has been held to require trust in the role of fairness of the organisation toward its management (Fruhen et al., 2013) and the role in fairness of management toward employees. Identified differences in management structure between aircrew and engineers was highlighted in the focus group data as a possible cause for experiences, which corroborates findings reported by Fruhen et al. (2013) in which a 'flat' hierarchy in air traffic control used communication as a means to enact positive safety while a more traditional hierarchy structure controlled safety through use of accountability. Additionally, there has generally been a strong focus on creating a just environment amongst pilots and cabin crew in civilian aviation. This is known as crew resource management and focuses on interpersonal communication, leadership, and decision making aboard the aircraft (Helmreich, Merrit & Wilhelm, 1999) but has yet to receive as much attention in the engineering sphere.

4.4.6 Training & Experience

While much of the discussion related to training revolved around dissatisfaction with non-flight related mandatory H&S training, ensuring that employees are well trained has two practical impacts on safety. Firstly, a lack of training has been shown to be related to increased numbers of errors, and thus can directly impact employee safety behaviours (Diaz-Cabrera et al, 2007; Hudson et al., 2002; Lawrie et al., 2006; Lu & Shang, 2005). Secondly, training is likely to lead to increased confidence and the ability to cope in high pressure or unusual circumstances, sometimes known as resilience (Fernandez-Muniz et al., 2007). Used to inform employees of risks in the workplace, a higher frequency of safety training has been positively associated with more favourable safety climate (Lu & Shang, 2005). Military aviation participants appeared to consider experience as declining over time, due to restrictions in, for example, flying time/variety of flying manoeuvres. However, it is unclear whether this reflects an actual decline/deficit, or a potentially 'rose-tinted' view expressed by older/more experienced personnel.

4.4.7 Organisational Commitment

The final identified theme in the research, organisational commitment, appeared to reflect a level of personal pride in the safety reputation of the FAA, and a sense of individual 'belonging' to the FAA. Although not widely reported in safety culture and climate research (Flin et al., 2000; Guldenmund, 2000), similar findings have been interpreted from civilian aviation research studies. Firstly, Patankar (2003) identified a factor labelled 'Pride in company' and secondly Fruhen et al. (2013) reported that safety improvements were seen to create a sense of pride amongst a sample of air traffic controllers. Block, Sabin and Patankar (2007) built on Patankar's 'pride in company concept' within a further aviation organisation and showed that two drivers of safety outcomes were organisational affiliation/identity and proactive management. The impact of this pride/commitment on safety and safety behaviour are, as yet, unclear.

4.4.8 Summary

Factors such as the hierarchical structure, bureaucratic nature and social system of the FAA appeared to affect the understanding and experience of military aviation personnel with relation to flight safety, safety culture and risk decision making. These findings have detailed a contextualised set of experiences in which personnel interpret their work environment and undertake potentially high-risk operations on a daily basis. In addition to providing a data driven foundation for the quantitative phase of the study, the findings from this exploratory, qualitative study may play an important role in interpretation of future quantitative findings.

4.5 Conclusions

The aim of this study was to explore participant accounts of norms, values, attitudes and behaviour in relation to safety, with a particular focus on structural and socio-technical elements that could be considered to constitute core influences on workplace safety culture. To achieve this, the study used focus groups to generate data, achieving the objective of sponsoring open and free discussion of the prevailing safety culture(s), therefore meeting objective one.

The study met objective two (identification and articulation of a set of core constructs considered to characterise headline influences on military aviation workplace safety culture), through a thematic analysis of the data. Seven themes were considered to be the most salient, core influences on safety within the organisation. These were; *policy & procedures*, *pressure*, *leadership & safety ownership*, *individual & collective responsibility*, *communication*, *training & experience* and *organisational commitment*. A summary of the primary features of these themes is provided below.

- Procedures were presented as having strong cultural legitimacy, that is they were generally viewed by personnel as being both necessary and appropriate. However, a range of notable barriers to compliance were identified.

- Policy was viewed by personnel fairly cynically, with levels of accountability and bureaucracy perceived to have increased in recent years. This was said to have left personnel feeling personally vulnerable in the event of unintentional violations.
- The dominant source of pressure experienced by personnel was an over-arching requirement to deliver operational capability, the type of which was arguably not reflected in most civilian sectors, with the exception perhaps of the emergency services.
- Adequate provision of resources, including personnel, equipment and time were described as key to the ability of personnel to work safely.
- Supervisors were cast as role models, leading by example and teaching behaviour, both in positive and negative aspects (i.e. encouraging either compliance or short cuts).
- In contrast, the motivations of senior management were viewed rather cynically.
- The ways in which the concept of just culture was applied to the workforce appeared to vary by function; aircrew participants appeared confident that they would be treated fairly on making an error, but this perception was not necessarily shared by engineering participants.
- There was a strong, overriding sense of organisational commitment, personnel were proud to belong to the FAA and took pride in its good safety reputation.

The findings from the thematic analysis were compared and contrasted with published findings within Sections 4.3 and 4.4 of the current Chapter (meeting the final objective of the study). A notable proportion of the themes identified in this study are supported by published literature, however the way in which they are operationalised within the FAA are considered to be specific to this military naval aviation population.

The findings suggest that the influences on safety in the FAA are multi-faceted, and are potentially influenced by the hierarchical, military organisational structure, the aviation context and the highly cohesive nature of this population. These findings were considered to provide a sound basis for development of a quantitative safety climate measurement tool, discussed in Chapter 6.

Chapter 5: Ranking Priorities for Safety Improvement (Study 2)

5.1 Introduction

5.1.1 Purpose of the Project and Rationale

Effective safety management relies on the ability of organisations to implement safety systems, determine their effectiveness through monitoring of risk management performance, learn from past events and identify vulnerabilities to determine priorities for improvement. Feedback from, for example, accident/incident reporting systems, audits, safety committee actions and employee concerns raised through workshops, focus groups and safety climate surveys can all inform organisational learning. Evidence-informed strategic decision making within organisations is crucial as it relates to determining where to allocate often finite resources to those risks/hazards/interventions which may have the greatest impact in improving safety. To achieve this some form of priority setting is required (Centre for Environment & Risk Management (CERN), 1997).

As a complement to Study 1, it was decided to explore what frontline personnel saw was the priorities for intervention, and to explore the extent to which their perspectives and views varied across different segments of personnel. Published findings indicated that the results of ranking exercises are prone to vary depending on the ranking method selected and design of the task (Fisher et al., 1968; Mullen, 1999; van den Fels-Klerx et al., 2017). In recognition of this, the study compared the results of three widely applied priority ranking techniques. Findings are of relevance to the current study, but also to the wider literature on the strengths and limitations of ranking techniques.

5.1.2 Aims

The aims of the study were to:

1. Characterise employee perspectives on the relative primacy of headline influences on safety in the FAA.
2. Compare the performance of three widely used alternative methods of ranking priorities and comment on their fit with the FAA requirements for a prioritisation method.

5.1.3 Objectives

The objectives of the study were:

1. To identify and define a set of themes that could be considered to characterise core components/influences on safety climate in the FAA.

2. To identify and compare the product of three alternative, widely applied ranking methods.

3. To provide comment on the strengths, limitations and performance of alternative methods for eliciting employee views on priorities for safety management, improvement or intervention.

4. To provide comment on the utility of safety issue priority ranking with respect to its potential role and contribution to risk management.

5.1.4 Background

Accessing employee safety perspectives using multi-dimensional safety climate surveys has been widely adopted, initially within the major hazards sectors, and now more broadly across many sectors. Proponents of this approach have suggested that such tools are particularly amenable to the development of safety profiles, that they allow statistical testing of differences between organisations or functional units within a single organisation, are intuitive/simple to use and allow organisations to identify areas of weakness (Alhenmood et al., 2004; Guldenmund, 2007; Zohar, 2010). A recognised limitation of safety climate/culture surveys is that, while providing a rating on each constituent scale, they offer little information about the importance of each construct (scale) relative to the others. These surveys treat each component as discrete and unrelated, and so the relative performance of each component can only be inferred from the comparison of aggregated ratings from each scale.

However, aggregating ratings into rankings in this manner (i.e. ranking scales by mean responses) has acknowledged shortcomings; it is arithmetically possible for group means to correlate highly with rating order, but that little to no positive correlation exists at the individual level (Russell & Gray, 1994). Therefore, they are held to have the potential to produce atypical aggregated ranks to the individual components and so might not reflect the individual's views to any degree. Subsequently this could make it difficult to determine the degree of agreement between individuals as to the accuracy of this ranking (Antonak & Livneh, 2000).

When using ratings each item is absolute and so the scoring functions used by respondents are not calibrated (Bockenholt, 2001). This means that one respondent's 5 could be another respondent's 3 (on a 1-5 scale), some may use the entire rating range (1-5) and others may limit their responses to a part of the rating scale (rating no items above a 3). The difficulty in this lack of calibration further complicates the decision on how to combine these responses in order to get an overall ranking of each multi-item scale.

Some have suggested that shortcomings of using rating scales might be addressed through the use of ranking methods (Bock & Jones, 1968), an approach that has been widely adopted within the area of risk management. Unlike ratings, ranking allows respondents to consider items in relation to each other, calibrating each item against the other items. Rankings force respondents to differentiate more incisively between items than do rating methods (Maio, Roese, Seligman & Katz, 1996), which could be seen as an advantage when prioritising areas for safety improvement. Ng (1982), in support of ranking methods, cited a study by Rankin and Grube (1980) which recommended the use of ranking above ratings as a means to help respondents discover their own implicit hierarchy in relation to related concepts (in their case, values). The use of ranking methods has, however, received little attention in the safety culture/climate area (Brockenholt, 2001).

If it is accepted that an insight into ranking priorities for intervention may be valuable to safety practitioners, this gives rise to a question regarding how stable and robust ranking methods are in identifying safety priorities. As applies to the testing of aggregated survey data from safety climate measures, the quality and robustness of the data generated by ranking methods requires careful consideration of the approach taken. Experimental findings have suggested that different elicitation methods can significantly affect ranking outcomes (Ali & Ronaldson, 2012). If the choice of technique leads to different orderings, this is said to run the risk of different conclusions being drawn, dependent on how the ratings are manipulated and combined (Fisher et al., 1968; Mullen, 1999; van den Fels-Klerx et al., 2017).

Conceived of as a lead indicator, the FAA has for several years used an in-house designed tool to periodically assess personnel perspectives on safety 'culture' (Zar et al., 2002). The method underpinning the tool is not a safety climate/culture assessment in the widely-encountered employee survey format, rather it is a ranking task designed to elicit employee views with respect to identifying priorities for improvement. The tool, a priority sorting task based on the Q method, mirrors the technique advanced by O'Reilley, Chatman and Caldwell (1991) to determine whether a potential employee would 'fit' in to an organisation by using a sorting task to compare an individual's 'culture' to an organisation's 'culture'. Adapted for use in the safety domain, the tool used by the FAA is described in more detail in

Section 5.1.5, but essentially represents a ranking task, with twenty-one items referenced to different aspects of safety.

5.1.5 Techniques for Ranking Priorities

The requirement to establish priorities can occur at various levels; governments need to decide how to reduce risks in areas such as healthcare, the environment and transport (CERN, 1997) while organisations may need to monitor/prioritise local hazards and risks. This is often achieved using risk registers, which have priority setting as a central feature; these are tools for risk management, and typically use some form of subjective ranking or rating method. Risk registers operate at a macro level as they can be used to inform policy options and identify how best to deploy resources (Baker et al., 2014) and allow monitoring of changes over time. The following section details how comparative risk ranking has been used in practice to prioritise risks.

<u>Plant Health Risk Register</u>

The UK's Department for Environment, Food and Rural Affairs (DEFRA) utilises a risk register model to manage and prioritise risks of pests and pathogens, allowing systematic consideration of risks to tree health and bio-security in the UK (Barnett & Weyman, 2016). However, it was noted that different combinations of likelihood and risk factor scores may equate to the same overall risk measure and therefore it may be more difficult to determine the priority level of different risks (Baker et al., 2014). To inform this risk register model, DEFRA utilises the judgement of experts to deal, in part, with the uncertainty of how these identified risks may be reduced through mitigation (Barnett & Weyman, 2016) and aid in prioritisation. However, significant variability between experts has been seen as a result of heuristic biases and differences in knowledge domains of the experts (Barnett & Weyman, 2016) and so use of experts in risk ranking has acknowledged limitations.

<u>United States (US) Environmental Protection Agency (EPA)</u>

Originally rooted in efforts to establish safe limits of exposure to toxic substances, the US EPA uses risk ranking to characterise the nature and magnitude of risks to human health from numerous environmental stressors (National Research Council, 1994). This government body produced a guidance document to inform state and local risk ranking exercises to promote scientifically robust deliberations, using comparative risk rankings. The importance of this was thought to lie in creating robust methods ensured that small risks did not receive unwarranted attention and the expense of neglecting large risks (Fischhoff & Morgan, 2013). The EPA suggested that priority setting often occurs within institutional, social, political, technological and economic realities, therefore risk ranking is inherently a subjective process (EPA, 1993).

European Union (EU) Risk Ranking Method (RRM)

The EU RRM was developed to promote consistency for ranking the risks of chemicals manufactured in the EU according to their potential risks to both humans and the environment (Hansen et al., 1999). The EU RRM utilises variables such as environmental exposure and effect as well as human health rankings to create an aggregated risk ranking and importantly highlights the use of the professional judgement of experts to address the uncertainty surrounding some of the risks of chemical exposure (Hansen et al., 1999). According to these authors, through using the EU RRM, EU states are able to create their own risk registers and therefore draw up appropriate risk management mitigation strategies.

Each of the three examples of the use of comparative risk ranking in priority setting has acknowledged, at some point in their development, the importance of ensuring that the methods used to rank risks was scientifically robust and transparent (Hansen et al., 1999). Following this acknowledgement, if a comparative ranking method was to prove useful in the safety culture and climate arena, the robustness, reliability and utility of the output of the method in relation to setting priorities for safety management must be assured. The current study therefore proposed to conduct a systematic comparison of alternative, widely applied comparative ranking techniques to characterise headline influences on safety in a military aviation context.

5.1.6 Review of Ranking Techniques

In the first instance, a review of alternative ranking techniques was undertaken, including the method currently used by the FAA (a Q-Sort). In general, options existed to use either individual ratings (independent ratings) or aggregated (group) ratings and typical techniques used in this area included:

Individual ratings:

1. Non-comparative approaches such as subjective rating scales (principally Likert and Thurstone).

2. Comparative approaches such as Q-Sorts, magnitude estimation, direct ranking, the method of paired comparisons and repertory grid.

Group ratings:

1. Delphi method which combines rating and ranking (mixed method approach).

A short summary of each of these approaches is outlined below, with particular focus on their application within published safety research.

Non-comparative Approaches

The most widely encountered strategy for quantifying attitudes/perceptions, both in the safety domain and wider psychological research, is using multi-item scales which are then averaged or summed to produce a numerical score (Ho, 2016). This approach is considered non-comparative; each item is evaluated one at a time, with the respondent asked to make an absolute judgement about the extent to which that item reflects their attitude/perception/belief/value (Oppenheim, 2000). Non-comparative response formats are typically a bounded scale such as a Likert scale (e.g. 5-point scale from strongly agree to strongly disagree) or Thurstone scales (where each of an array of anchors has a numerical value indicating the respondent's degree of response, from which an average is computed). In the safety domain Likert rating scales tend to be the preferred method due to their simplicity (Oppenheim, 2000).

The advantages of a non-comparative (rating) approach are held to be that it is intuitive and easy to administer, that it allows collection of information in a standardized manner (Rattray & Jones, 2007) and is relatively quick and simple to use (Scheibe et al., 2002). Data gathered in this way is amenable to a wide range of statistical analyses, allowing group comparisons using means and standard deviations (Guldenmund, 2000; Oppenheim, 2000; Russell & Gray, 1994) which rankings generally do not.

However, rating scales have been criticised as being particularly susceptible to 'yea saying' (where there is a tendency to agree or disagree with all statements) and primacy/recency effects, where people are more likely to choose the first category or last category (Chan, 1991). Significant skewing (creating ceiling and floor effects) of the data might occur if items are all seen as either important or un-important (DeCarlo & Luthar, 2000). Paradoxically, the advantage of being easy to complete has also been cited as a driver of reduced data quality, response sets and restricted ranges (Alwin & Krosnick, 1985). There is little consensus as to whether an even or odd number of response points for rating scales should be used, with advocates arguing that respondents may have neutral views (and thus require a neutral mid-point) and critics raising the issue of increased potential for acquiescence (Robinson, 2018). The impact of unreliable or low validity rating scales on research findings is large (Robinson,

2018) and so robust psychometric development of tools using rating scales is integral to their utility.

Comparative Approaches

In contrast to some of the limitations of the non-comparative method described above, comparative methods are held to be more robust against uniform bias (Aday, 1996; Brown & Maydeu-Olivares, 2013) and are said to increase validity in their characterisation of the target being rated (Serfass & Sherman, 2013). Here, instead of considering items independently, respondents are required to consider each item in relation to every other item. This is held to encourage respondents to consider their answer more carefully (Prasad, 2001) while allowing them to still interpret statements with their own understanding.

However, the principle criticisms of comparative approaches are that they are known to be time-consuming and often difficult for respondents, demanding concentration which can be particularly problematic if there is a long list of items to compare (Alwin & Krosnick, 1985). The comparative approaches reviewed for consideration in this study were Q-sorting, magnitude estimation, direct rank ordering, the method of paired comparison, repertory grid and the Delphi method. Each of these is discussed in turn.

Q-Methodology (Q-Sorts)

Developed in the 1930s (McKeown & Thomas, 1988), Q-Methodology was devised as a means by which to quantify subjective concepts through consideration of an individual's pattern of responses (Coogan & Herrington, 2011). When used as a ranking method, a Q-sort requires respondents to 'sort' statements in reference to a criterion (most/least agreed or most/least like me) in a distribution that ensures fewer statements are places at the extremes, with greater numbers in the middle (neutral) position (McKeown & Thomas, 1988). This method has been adapted and used in organisational culture research (Chatman, 1989; Ryan & Schmit, 1996) to compare an individual's values to an organisational value profile in order to determine the degree to which the individual's values 'fit' with the wider organisational values. This was achieved by comparing the two value profiles and, if large differences were seen, these were said to indicate specific areas in which there was a lack of 'fit' (Caldwell & O'Reilley, 1990). Unlike traditional Q-methodology (as is used in personality testing), using Q-Sorting as a ranking technique does not utilise the factor analysis of an individual's Q-Sort, but is similar in many ways to direct ranking, but using a forced/forced free distribution of sorting categories.

Q-Sort ranking is widely used in psychology research (Serfass & Sherman, 2013) and unlike in direct ranking, several items can be given the same rank. It has therefore been described as more flexible and able to capture the dilemmatic nature of everyday thinking (Walker, Simmons, Wynne & Irwin, 1998) than, for example, the direct ranking method. However, Q-Sorting has been criticised for being particularly susceptible to order effects (Serfass & Sherman, 2013) and, when ranking many items, might be too cognitively complex to generate reliable results (Dziopa & Ahern, 2011). Critics also highlight that having a forced distribution for the responses may compel respondents to make discriminations that they might otherwise not be inclined to make or exaggerate the difference between the statements (Eyvindson et al., 2015). A description of the FAA's safety culture monitoring tool based on the Q-Sorting method is provided below.

The FAA Flight Safety Q-sort

The FAA utilise a tool that was developed in 2002 by the Centre for Human Sciences, with the stated aim of measuring safety culture (Zar et al., 2002). The items contained within this tool, however, show notable similarity with safety climate tools (Flin et al., 2000; Weigmann et al., 2004; Zohar, 2010) and much of the literature on which the tool was based related to safety climate rather than safety culture. The Flight Safety Q-Sort is a paper and pen exercise that requires respondents to sort a 21-item statement set (Table 1, Appendix C) two times. Respondents rate each of the 21 items on a seven-point scale using a forced-free distribution containing seven 'piles' (the frequency of each pile is a 2, 2, 4, 5, 4, 2, 2 quasi normal distribution characteristic of the Q-method, Block, 1978). Respondents are instructed to first consider what their 'ideal' unit might look like and second to consider what their 'actual' unit is like, thus completing a sort of the 21-items twice.

At the end of the sorting process a profile for the individual's perception of an 'ideal' organisation and their 'actual' organisation are compared by considering the placement of items on the 'ideal' and 'actual' sorts (Block, 1978). Where aspects of an individual's 'ideal' organisation are ranked higher than their 'actual' organisation this was suggested to highlight areas of flight safety concern (Zar et al., 2002). During analysis of the historical data collected using this tool, a high degree of non-adherence to the forced distribution scale and low levels of concordance between individuals with regard to areas of concern were identified as limitations of the method (Ashford, 2016). The large number of items, some of which display significant redundancy (see items in Table 1, Appendix C), were identified as a potential source of confusion amongst respondents (Ashford, 2016). Section 5.2.3 further details the process by which the items contained within the FAA Flight Safety Q-Sort were refined for use in the current study, informed by the wider literature (Chapter 2) and qualitative findings from Study 1 (Chapter 4).

Fixed Modulus Magnitude Estimation

Magnitude estimation is a technique that has most widely been used in psychophysics to measure subjective sensations of objective variables such as brightness, warmth and loudness (CERM, 1997) but has also been utilised in attitude research (Welch, 1971). In fixed modulus magnitude estimation, typically, respondents are given one item (a stimulus or item) as a 'base statement' or 'reference stimulus' with a value, and then asked to rate all the other stimuli/items in comparison with the base/reference (Welch, 1971). For example, if a statement is considered double that of the base standard, then it will be allocated a number '2'.

Supporters of magnitude estimation suggest that it is a simple and easy technique for respondents to grasp and displays good discriminatory capacity when compared to simple category scales (Welch, 1971). The production of ratio level data is also seen to be an advantage (Welch, 1971; Purdy & Pavlovic, 1992). However, critics of magnitude estimation cite the lengthy nature (Anderson, Basilevsky & Hum, 2013), high inter-individual variability of resultant data (possibly reflecting response biases in the ways people go about making estimations) and difficulties in displaying adequate test-retest reliability (Purdy & Pavlovic, 1992) as limitations of this method.

Direct Ranking

Direct ranking requires respondents to rank objects, items or statements according to a criterion, with all of the items being presented simultaneously (Chalwa & Sondhi, 2011). For example, an individual is asked to rank five soft drinks (Coca cola, 7-up, Fanta, Pepsi and Sprite) from 1 (favourite) to 5 (least favourite). This technique has been extensively used in market research (Gracia & de-Magistris, 2016) and student test marking calibration (Curcin, Black & Bramley, 2009). This method has also seen use in the safety domain for ranking organisational priorities (Nordlof et al., 2012).

Stated advantages of this approach are that it has intuitive appeal due to its apparent simplicity, that it is easy to set up and apply with a small number of items (Droba, 1932) and that it is more efficient than, for example, the paired comparison method (Curcin, Black & Bramley, 2009). However, it has been noted that as the method requires comparison of all items consecutively, the cognitive demand of the process will depend on the number of items in this list to be ranked (Seaton, 1974) and so may become unwieldy with large numbers of items (Ali & Ronaldson, 2012; Nordlof et al., 2012; Scheibe et al., 2002; Thurstone, 1959). The resultant cognitive overload is held to have the potential for reducing test-retest reliability or reproducibility in rankings (Ali & Ronaldson, 2012; Weyman et al., 2006). Direct ranking has further been criticised for being difficult for respondents to use if the items are multi-faceted or multi-attributional (Bock & Jones, 1968). Unlike magnitude estimation, results from direct ranking can only be considered ordinal level data (Droba, 1932; Scheibe et al., 2002) and so the method has been suggested as limited when attempting to identify stand-out items or risks (Susel et al., 2016).

The Method of Paired Comparisons

The method of paired comparisons originates from the work of Thurstone (1927), and involves respondents being presented with pairs of items and asked to indicate which of the pair is preferred (CERM, 1997). Each item is compared against every other item, one pair at a time. This information is then used to produce a scaled ranking of the items (Hunns & Daniels, 1980) as each full set of choices yields a preference score (Brown & Peterson, 2009). The method of paired comparisons has been widely applied to perceptual and attitudinal topics such as perceptions of risk (Ostberg, 1980; Susel et al., 2016; Weyman et al., 2003), trust in government agencies (Pidgeon et al., 2003), patient safety priorities (O'Hara et al., 2012) and assessment of image quality (Mantiuk, Tomaszewska & Mantiuk,1981).

Supporters of this method suggest that it is more robust than other ranking techniques as it allows calculation not only of the sequence in which items are ranked, but the relative distance between them (Oppenheim, 2000). The resultant ranking is in the form of a ratio rather than an ordinal scale (Purdy & Pavlovic, 1992) as it is based on the number of times each item dominates the rest (Susel et al., 2016). As it is possible to determine the relative distances between the items, this has often been used to indicate the degree of discrimination between them (Droba, 1932). Proponents of this method also cite its simplicity as an advantage as only two items are compared at a time (Bernard, 2012; Chalwa & Sodhi, 2011). Furthermore, the method has been shown to have good test re-test reliability (Bock & Jones, 1968). Although most ranking methods are amenable to statistical testing of between-person agreement (concordance), the method of paired comparisons allows further statistical testing to assess the degree of internal consistency (within respondents, Brown & Peterson, 2009).

However, critics of the method claim that the requirement to compare each item with every other item means that only a limited number of items can be used; generally, a maximum of nine items (36 paired judgements) for a complete paired comparisons design is recommended (Chalwa & Sodhi, 2011; Ock et al., 2016; Weyman et al., 2006). An incomplete design is possible and permits a larger item set, however this also significantly increases the required sample size (Wilson & Corlett, 1995). This method has also been criticised for being time consuming to complete (Scheibe et al., 2002), with some authors reporting few differences in results when compared with rating scales (Fisher et al., 1968).

Repertory Grid

The repertory grid was invented by George Kelly, within his personal construct theory, to study personal and interpersonal systems of meaning, and has since been adapted for a broad variety of topics (Demsey & Neimeyer, 1995; Marsden & Littler, 1998). Repertory grid systematically assesses the relationship between a set of constructs and a set of elements and is normally a three or four stage process, with breaks between each stage for assimilation and integration of the data. Typically, a set of elements are determined which are then presented in groups of three, to which respondents are asked to explain ways in which any two elements are the same but differ from the third. This allows the development of constructs (which are described in bi-polar terms) on which the elements differ. Each of the elements can then be ranked or rated on each of the construct dimensions (Demsey & Neimeyer, 1995), and the resulting matrix analysed statistically using correlation and factor analysis (Calisir & Lehto, 2001).

Yorke (1983) suggested that, when a ranking repertory grid is utilised, it is particularly susceptible to 'bunching' and therefore often does not provide fine discrimination between elements. While this method is particularly useful when exploring topics about which little is known, it focuses on the personal or local system of meaning, with no assumption that these generalise to other people (Demsey & Neimeyer, 1995).

Delphi Method

While the preceding methods have all involved individual ratings, the Delphi method aims to generate a structured group opinion (Goodman, 1987) through a prescribed set of procedures applied to a pre-determined expert panel (Powell, 2003). Typically conducted in up to three rounds, this method utilises a set of questionnaires. The first is generally unstructured and returns qualitative data which is used to create a set of items. These items are then quantified in further rounds through ranking or rating techniques (Powell, 2003). Between rounds the researcher provides feedback to the group members about the opinions and ratings of other group members, thereby encouraging a convergence of opinion. The classical Delphi method is characterised by: (i) an anonymous group of respondents, thereby promoting free expression of ideas/opinions, (ii) iteration which allows respondents to refine views each round considering group opinions, (iii) controlled feedback during each round and (iv) statistical aggregation of views to allow quantitative analysis (Rowe & Wright, 1999).

The Delphi method has been used for exploring policies and values (Scheibe et al., 2002; Skulmoski, Hartman & Krah, 2007), subjective safety management issues (Baker, Bouchlaghem & Emmitt, 2013) and perceptions of construction safety (Jebb, 2015). Supporters of this method have suggested that it allows rigorous capture of qualitative data (Rowe & Wright, 1999), allows achievement of consensus in areas of uncertainty or lacking in empirical evidence and can widen knowledge and stimulate new ideas (Powell, 2003). Proponents of this method have also suggested that the negative aspects of group interaction are minimised (social pressure, personal/political conflicts) while the advantages (such as gaining knowledge from a variety of sources and creative interaction) are maximised (Rowe & Wright, 1999).

However, critics of the method have suggested that it requires extensive time commitment and may lead to a diluted version of individual opinions (Powell, 2003) due to encouraging conformity in views that may not exist otherwise (Bardecki, 1984; Goodman, 1987; Rohrbaugh, 1979). While those who take part may reach agreement, the process of doing so might render the consensus view unlike that held by people outside of the group. The recommended sample sizes using this method vary considerably, with homogenous groups said to require ten to fifteen people, whereas heterogeneous samples might require several hundred (Delbeq et al., 1975).

Summary and Rationale for Chosen Methods

While either ranking or sorting procedures can be applied to prioritise risks, these methods should display several features, including (Floyd & Footitt, 1999; Hansen et al., 1999):

1. They must allow identification, assessment and development of priorities within the specific context in which it is to be used.
2. They must be simple, unambiguous and straightforward to perform.
3. They must consistently give the 'correct' answer such that, when aggregated, judgements should not produce a ranking that is atypical of individual judgements.
4. That the chosen method should support the capacity to determine the degree of consensus between raters/experts (CERM, 1997).

Each of the methods reviewed would, to varying degrees, facilitate a form of prioritisation/ranking and were considered for use in the current study. As the FAA already utilised a comparative ranking method (based on Q-Sorting), a Q-Sort method was included in the study. Decisions regarding the choice of which alternative methods to use were made partly on their capacity for comparing or corroborating prioritisation results, and partly on the technical aspects, strengths and limitations of each method, when compared with the others, guided by the features stated above.

Magnitude estimation was initially considered an appropriate method as the output would have provided a ratio ranking, which would be an advantage when comparing results against an ordinal Q-Sort rank order. However, it was subsequently discounted due to its reported tendency toward high inter-individual variability which was likely to impact both on the ability to aggregate the data and gain acceptable consensus between raters.

Repertory grid was discounted as a method as it would not allow comparison between individuals and appeared better suited to exploring individual systems of meaning and personal constructs than shared perceptions of safety priorities. The method was also not considered simple or unambiguous to perform, and given its known limitation when applied to generalisation, it did not fit with the aims of the study.

The Delphi method, although robust, was discounted as it would have resulted in a group consensus decision regarding safety priorities, as opposed to individual rankings. Using this method, no comment could have been made on the degree of agreement between individuals, as the output is a decision made by consensus. Therefore, there would be no means of independently determining the degree to which personnel had a shared view on safety, which some of the other ranking methods would support.

Direct ranking was considered appropriate for inclusion as it allowed consideration of concordance between individuals, it provided ordinal rankings which could be compared with the Q-Sort rank order, and could use the same discriminant criterion as a Q-Sort ranking, thus allowing a more direct comparison between the methods.

The method of paired comparisons was also considered suitable for inclusion as it allowed for production of a ratio rank order, it allowed consideration of concordance between individuals (and additionally was amenable to calculation of intra-individual concordance) and could make use of the same discriminant criterion as a Q-Sort might.

5.2 Method

5.2.1 Ethical Approval

Permission to undertake the study was granted by the University of Bath (Reference: Ethics 17-132). MODREC was approached but determined that as one of the methods being tested was already in use by the organisation, the study did not require ethical consideration by MODREC (Reference email dated 20/03/17 from MODREC Secretariat to the author).

5.2.2 Study Design

The study was a within-subject, repeated measures design, with all respondents completing all ranking methods. Respondents each undertook three ranking/sorting exercises (direct ranking, Q-Sorting and the method of paired comparisons) on a single set of safety dimensions considered relevant to this population.

5.2.3 Development of Materials

Figure 3 graphically summarises the stages involved in the current study, each of which were described in detail in the following sections.

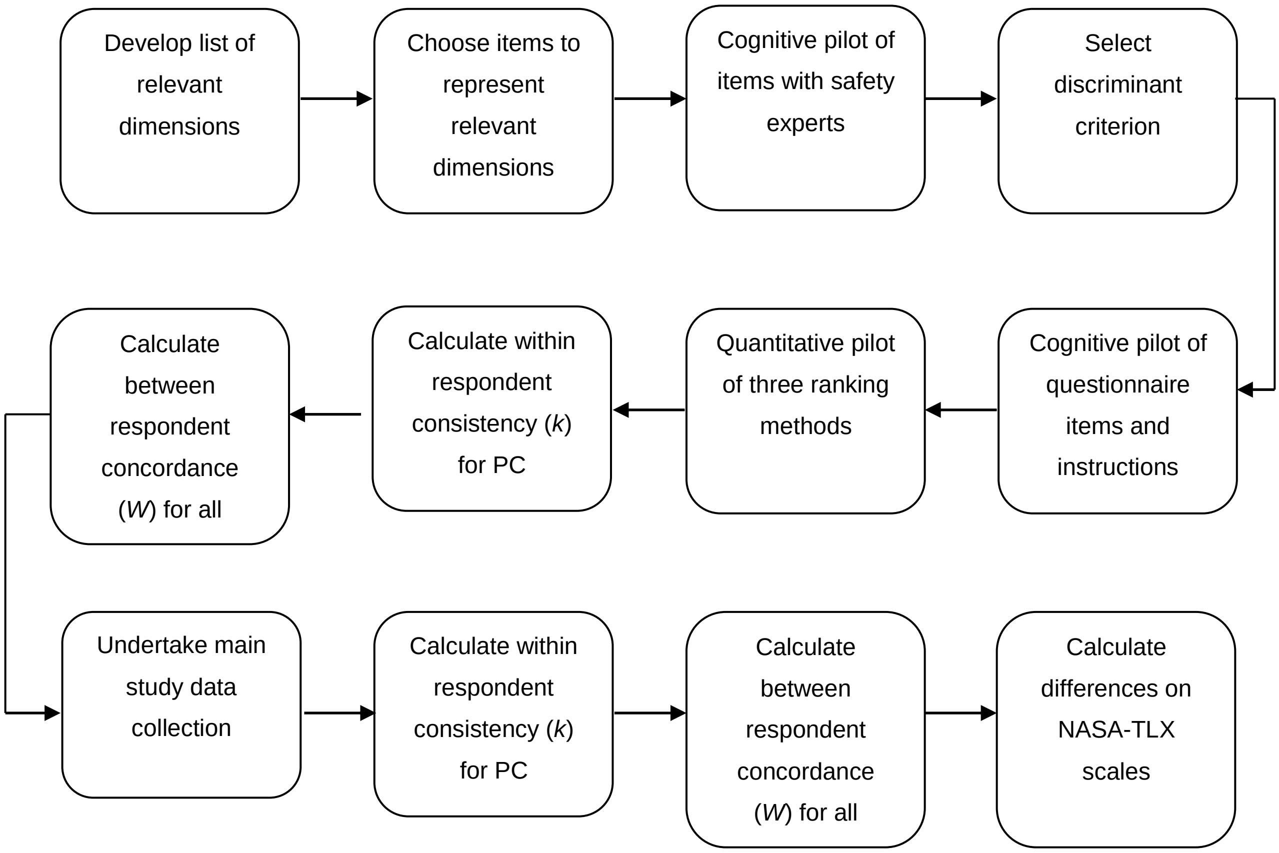

Figure 3. Summary of the stages involved in the current study (where *k* is Kendall's coefficient of consistency, *W* is Kendall's coefficient of concordance and PC is paired comparison method).

Determination of the Item Set

To determine the items which would be used, themes/dimensions from the FAA Fight Safety Q-Sort were considered alongside findings from Study 1 (Chapter 4) and the review of literature (Chapter 2). Although there were 21 items contained within the FAA Flight Safety Q-Sort, these were based on a smaller number of dimensions, each of which was represented by more than one item (Table 1, Appendix C). The dimensions/themes from Study 1, Chapter 2 and the FAA Flight Safety Q-Sort are summarised in Table 14, and were all considered potentially pertinent to a military aviation population.

Table 14.

Comparison of safety culture/climate themes/dimensions from Study 1, the FAA Flight Safety Q-Sort and the Review of Literature.

Study 1 themes (Chapter 4)	Themes from FAA Flight Safety Q-Sort	Review of Literature (Chapter 2)
Policy, rules and procedures	Safety systems, procedures, policy	Rules and procedures
	Priority of safety	
Leadership/management ownership	Management commitment/actions	Management/supervision
Individual responsibility	Individual actions/responsibility	Personal involvement/ employee participation
Risk perception/ consequences		Risk/hazard level
Just culture, reporting and feedback	Communication	Reporting systems
Training/experience	Safety training	Training/education
Organisational commitment		
	Working environment	
Pressure (resources)	Resourcing	Work pressure/resources
		Competence
		Safety systems

Table 14 shows that the FAA Flight Safety Q-Sort contained eight dimensions, while Study 1 (Chapter 4) and the review of literature (Chapter 2), identified eight dimensions and nine dimensions respectively. While there was considerable overlap between the dimensions, some were unique to each source and none of these is claimed to be definitive or exhaustive. Notably absent from the seven FAA Q-Sort dimensions were two aspects identified in the other sources. Both Study 1 and Chapter 2 identified competence/experience as having an important influence on safety (Study 1 showed that military aviation personnel discriminated between training and experience, and to be simply trained was not accepted as being competent to undertake the role, while Chapter 2 showed competence to be considered a separate issue to training). Secondly, the dimension of pressure was identified in Study 1 and Chapter 2, with a key source of pressure for this population being a lack of human resources/manpower. Therefore, these two additional dimensions were considered important for inclusion, beyond the seven dimensions already currently in use.

Therefore, the final list of nine dimensions to be included in this study were; *individual actions/responsibility*, *management commitment/actions*, *priority of safety*, *safety training, communication, safety system/policy/procedures, working environment, human resources* and *competency/experience.*

Representation of Dimensions

Once the dimensions to be used had been determined, the question arose as how to best represent these to the respondents. While the dimensions could simply be used as the list to rank, the use of a representative statement (Pidgeon et al., 2003; O'Hara et al., 2014) or pictorial representation (Ostberg, 1980; Weyman & Clarke, 2003) had previously been justified on grounds of reduced complexity and ease of completion. As the current dimensions in the study did not lend themselves to pictorial representation, a representative statement for each of the dimensions was considered a suitable way to simplify the ranking exercise for respondents.

The chosen wording for representative items for each of the nine dimensions needed to be clear, unambiguous and reflect the essence of the overall dimension (Pidgeon et al., 2003). Items from the FAA Q-Sort tool, wording derived from findings from Study 1 and items from within existing safety climate tools (Chapter 2) were considered as potential representative items. From these, a list of four items per dimension were drafted (see Table 15). Items were all worded positively to ensure items would be comparable during ranking.

Table 15.

List of safety items considered for inclusion in the study, with frequencies of each rated as 'most representative' of the overall dimension during cognitive piloting.

Individual actions/individual responsibility	Frequency
Personnel in my unit understand the concept of flight safety	1
Everyone accepts that flight safety is their responsibility	1
Individuals are empowered to take action in the interests of flight safety	2
People here are clear about what their responsibilities for safety are	2
Management commitment/management actions	
Unit level managers take the lead on flight safety issues	2
The impact of change on flight safety is always considered by the organisation	
There is a just culture in my unit	1
Suggestions to improve flight safety are always followed up	3
Priority of safety	
Rules are not bent because of work pressure	
Flight safety is more important than cost saving measures	2
Flight safety risks are never taken to ensure that a job is completed on time	3
People do not take shortcuts, even when operational demand is high	1
Safety training	
Everyone receives the correct level of flight safety training	1
Everyone is fully trained to undertake the tasks that are required of them safely	1
Flight safety is an integral part of routine training	4
Everyone here is sufficiently trained to undertake their tasks safely	
Communication	
Incidents that have flight safety implications are always reported	
It is easy to report safety concerns	
In my unit it is appropriate to question instructions when flight safety is at stake	4
Individuals are comfortable reporting their own mistakes	2
Systems safety, procedures and policy	
Flight safety risks are considered in the normal planning/briefing cycle	3
In my unit procedures are in place to promote flight safety awareness	3
Procedures are properly designed to ensure safety	
Safety procedures are not just there to protect against legal action	
Working environment	
The work environment is always conducive to safe operations	2
All the necessary equipment is provided to allow tasks to be carried out safely	1
My workplace identifies hazards and identifies risks	1
Where I work, hazards are appropriately assessed and controlled	2
Human resources	
The correct numbers of personnel are available on my unit	3
There are enough people to do the job safely	3
Manning is appropriate to meet operational demands	

More people are made available to do their job if needed for safety reasons	
Competency/experience	
Competent personnel with the right levels of experience are available on my unit	1
People here are sufficiently competent and experienced for the jobs they are required to do	4
People here are always confident they have the right level of competency and experience for the job	
In general, people here are both competent and experienced enough to do their job safely	1

Cognitive Piloting of Item Sets

The items in Table 15 were subjected to a cognitive pilot with a group of six military naval aviation safety experts using a method which was modified from the Delphi technique. Initially each of the six experts worked independently and was asked to choose which of the four items characterised best the essence of the respective dimension. Table 15 shows the frequency with which each item was chosen to represent each dimension. This demonstrated that there was limited agreement with regards to the most representative item, particularly for the dimensions of *individual actions, working environment* and *management commitment*. The second stage of the modified Delphi process was to facilitate a discussion session amongst the experts, to determine a consensus on one representative item per dimension. This was completed one month after the cognitive pilot with four of the original six experts (operational commitments meant that two respondents were unable to attend) and was facilitated by the researcher.

In this discussion session, which took approximately sixty minutes, the respondents were first presented with the results shown in Table 15 and given cards on which each of the items were printed. One dimension at a time, respondents were asked to rank the items according to how much they reflected the overall dimension, discuss their rankings and come to a consensus as to the most appropriate item. Respondents were asked to consider which item was the clearest, least ambiguous, and of most use from a safety management perspective. They were also asked to consider any semantic issues with the wording of the items for the FAA context and several changes were subsequently made; 'risks', were renamed as 'Flight Safety risks', and 'incidents' were replaced with 'occurrences'.

Several dimensions, such as *safety training*, *safety system* and *working environment* appeared to be more amenable to encouraging consensus, and the ranking was performed quickly for these dimensions. However others, in particular *management commitment*, were not so easily defined, and the final item chosen required modification to its wording before all respondents conceded that the item was appropriate to convey the meaning of the dimension. On completion of this process, the nine items considered to best represent the nine dimensions are shown in Table 16.

Table 16.

Safety dimensions and corresponding item used in the ranking exercises.

Safety dimension	Item
Individual actions	Everyone accepts that flight safety is their responsibility
Management commitment	Individuals are empowered by their management to take actions in the interests of flight safety
Priority of safety	People do not take flight safety risks, even when work demands are high
Safety training	Flight safety training is an integral part of all routine training
Communication	Occurrences that have flight safety implications are consistently followed up
Safety system	Flight safety risks are considered in the normal planning/briefing cycle
Working environment	Where I work, hazards are appropriately assessed and controlled
Human resources	There are enough people to do the job safely
Competency /experience	People here are sufficiently competent and experienced to do the jobs they are required to do safely

Selection of the Discriminant Criterion

When considering the discriminant criterion against which the respondents would be required to rank the items, it was acknowledged that the facet which the items were ranked on would likely have a significant impact on determining discrepancies. During the cognitive piloting of the item set, it was noted that the experts considered each of the dimensions of importance when considering safety in a workplace, thus it appeared reasonable to assume that the presence of each dimension in a workplace might indicate one in which safety was considered important. However, as already noted in Study 1, the dimensions did not always appear to be equally visible to participants in different units/functions. Therefore, as a potential discriminant criterion it was considered appropriate to ask respondents to consider the degree to which each of the items was representative of their current workplace (i.e. which were most observed, and which were less so). Respondents should, arguably, reasonably be expected to observe their workplaces and make a subjective judgement of the degree to which the different dimensions were either present or absent. The reference criterion therefore asked respondents to rank the nine items according to how much like their current work unit each statement was. This ranged from 'Most like my current unit' to 'Least like my current unit'.

5.2.4 Materials

Presentation of the Items

The lack of availability of computing facilities for many of the sample population meant that paper and pen data collection methods were required. Each ranking/sorting method was presented to respondents in the form of a booklet. In all cases, the first page of the booklet contained instructions on how to complete the exercise. In the case of the direct ranking and Q-Sort exercises, the second and third pages of the booklet contained the nine items and the answer grid respectively. In the case of the paired comparison method, each pair of items was presented on a separate page, resulting in a thirty-seven-page booklet. While it is acknowledged for the method of paired comparisons that respondents would be able to 'check back' on their previous answers they were instructed to complete the booklet sequentially, without returning to previous questions. No respondents were observed to be 'checking back' during the data collection sessions.

Order Effects

To minimise order effects across the sorting/ranking tasks, the presentation of the three methods was counterbalanced across respondents using a Latin square design (Table 2, Appendix C). To minimise item order effects within each method, four versions of booklet for each method were made, each with a different presentation order for the items (as recommended by Serfass & Sherman 2013; Weyman & Clarke, 2003). This was particularly important in the case of the method of paired comparisons due to the highly repetitive nature of the task. Randomisation of the order of items was less crucial in the Q-Sort and direct ranking methods, but was conducted to align with the method of paired comparisons. In the case of the paired comparison booklets, paired items were presented equally often forward and backward (in line with recommendations made by Sjoberg, 1967) to avoid potential bias (Blasius, 2012).

Workload Measures

Comparative approaches have been criticised for being cognitively complex when compared to simple ranking exercises, particularly with larger numbers of items. To determine the subjective workload induced by each of the ranking methods, the NASA task load index

(TLX) was used (see Appendix C for NASA-TLX). This multi-dimensional scale, developed in 1988 by Hart and Staveland has been widely used in naval military (Gould et al., 2009; Bridger & Bennett, 2011), army aviation (Hill et al., 1992) and military aviation (Bittner, Byers, Hill, Zaklad, & Christ, 1989) contexts as an indicator of subjective workload. The NASA-TLX consisted of six sub-scales which represented a variety of independent clusters of variables considered to constitute workload experienced by people undertaking tasks (Hart, 2006). These variables are (i) mental demands, (ii) physical demands, (iii) temporal demands, (iv) frustration, (v) effort and (vi) performance. Respondents were asked to rate the magnitude of demand (on a scale of 0 to 100, marked to the nearest 5) on a bi-polar scale for each dimension (in line with Hill et al., 1992). The NASA-TLX has undergone appropriate validity and reliability testing (Hart, 2006) and is often used as individual sub-scales, sometimes referred to as the raw NASA-TLX (Byers, Bittner & Hill, 1989; Hendy, Hamilton & Landry, 1993).

5.2.5 Quantitative Pilot Trial

The item set was piloted with five FAA personnel, using the booklets devised for the study. Each person was asked to comment on the clarity of the completion instructions and on any ambiguity associated with the meaning of the nine items. All respondents stated that the instructions were clear, that they understood the items and that the items were discernibly different. To further check the suitability of the item set, within-respondent consistency was assessed for the paired comparison responses, i.e. to assess the discriminant properties of the item set, and the presence of intransitive triads of the type A>B>C>A. All respondents achieved acceptable internal consistency (k>0.70, see Section 5.2.8).

5.2.6 Sample

Respondents were recruited on an opportunity basis, from one squadron at each of two locations, from teams of personnel who were accustomed to working together (personnel were from the same watch/shift or flight crew). Prior information of the study was promulgated to potential respondents via squadron communication channels using a participant information sheet (Appendix C). Access to the participant sample was granted by the Chain of Command and data collection sessions were organised to limit disruption to operational activities. The sampling was targeted, in that personnel with a variety of ranks (junior ratings, senior ratings and officers) from the two major functions in the FAA (aircrew and engineers) were invited to participate. Data collection was undertaken on five separate occasions over a two-month period. A total of forty-five respondents participated in the study (see Table 17).

Table 17.

Demographic details of sample.

Location	Function	Rank
1 (N=13)	Aircrew (N=5)	Officer (N=5)
	Engineers (N=8)	Senior rating (N=3)
		Junior rating (N=5)
2 (N=24)	Aircrew (N=10)	Officer (N=10)
	Engineers (N=14)	Senior rating (N=8)
		Junior rating (N=6)

Note: N= number of respondents

5.2.7 Procedure

On the day of testing, respondents were fully briefed about the study (both verbally and in writing, see Appendix C), encouraged to ask questions and finally invited to participate. Volunteers signed informed consent forms prior to participating (Appendix C). Questionnaires were intended for self-completion, however the researcher remained available in case respondents had any questions. Time to attend the briefing and data collection sessions was scheduled within work time to ensure that additional demands were not placed on respondents. Each session took approximately thirty minutes, comprising a total of one and a half hours in total, over three sessions.

Respondents completed the ranking exercises at three time points; at the start, the middle and at the end of the working day, with at least four hours between sessions. On conclusion of each ranking exercise respondents completed the NASA-TLX and after the final session respondents also answered several short de-brief questions. This de-brief gathered information regarding whether respondents understood the point of the exercise they had completed, what aspects of their work environment they were thinking about when doing the exercise, and whether there were any safety dimensions that were not included which should have been.

5.2.8 Data Analysis

Respondents were required to rank nine safety statements according to a bi-polar criterion of *Most like my unit* to *Least like my unit*, using three methods; the direct rank ordering method, a Q-Sort method and the method of paired comparisons.

To test the consistency of responses it was important to determine the degree of consensus between respondents and the different ranking methods afforded variable scope for achieving this. All three methods allowed calculation of between-person concordance while only the method of paired comparisons was also amendable testing of within-respondent consistency. Description of these analyses are detailed below.

Method of Paired Comparisons

Calculation of Within Respondent Consistency (k)

Unlike the Q-Sort and direct rankling methods, the method of paired comparisons allowed for calculation of consistency within each respondent. Within this method inconsistencies might occur, for example, when a judge ranks item A above item B and item B above item C, but then ranks item C above item A. This situation is known as an intransitive triad (Kendall, 1948) and may occur when items are ambiguous or lack a 'just noticeable difference' (Thurstone, 1959) such that respondents cannot distinguish between the items.

To test whether any respondents displayed inconsistent responses, Kendall's coefficient of consistency (*k*) was calculated using the formula below:

$$K = \frac{12\Sigma\,(\mathrm{R}-\mathrm{r})^2}{N(N^2-1)}$$

Where: R=sum of rows (number of times an item was selected as more 'like my unit' than its comparison item); r = mean of R; N= number of items in set.

Varying from 0 (completely inconsistent) to 1 (completely consistent), a threshold *k* value of 0.7 or higher was set as an acceptable criterion (Cromer et al., 1984). If more than 10% of respondents were seen to exhibit poor consistency (k<0.70) then the method would be seen to be unsuitable for analysis (Bock & Jones, 1968). Following the Case V method (Thurstone, 1927) respondent internal consistency was assessed by calculating the number of intransigent triads present in each response set.

A total of four out of the forty-five response sets (8%) within the paired comparison method exhibited a lack of consistency (k<0.70) and so were excluded from the analysis. The corresponding data for these respondents for the direct ranking and Q-Sort methods were also removed. Data from two respondents were removed as they did not complete all three data collection sessions (these respondents were unable to attend the final session due to operational or medical reasons unrelated to the study), while a further two data sets had to be removed as respondents did not adhere to the response format requirements (one in direct ranking and one in the Q-Sort). This left a total of thirty-seven respondents whose data was subjected to further analysis. The final number of response sets was in excess of the minimum criteria (ten) for statistical calculations specified by Hunns and Daniels (1982).

Item Scaling

The method of paired comparisons also allowed construction of a scale derived from the frequency with which each item on the scale was ranked higher than all other items. In line with methods detailed by Thurstone (1927) and replicated in Ostberg (1980), Weyman and Clarke (2003) and O'Hara et al. (2014), respondent data sets were aggregated to create a frequency table. These were completed for all response sets and the frequencies were then converted into judgement proportions (Weyman & Clarke, 2003), after which they were transformed into standardised arcsine deviates (Ostberg, 1980). These arcsine deviates were then finally transformed by referencing these to the item most often ranked as 'least like my unit' (rank 1) to produce an interval scale with the lowest ranked item as the lowest point on the scale.

All Methods

Calculation of between respondent concordance (W)

The output of both the direct ranking and Q-Sort methods could be tested for between respondent concordance (*W*) directly, however ranking for the method of paired comparisons, further data processing was required. This was achieved by calculating the total number of times each item was 'preferred' to all other items in each response set. A rank of 1 was assigned to the item 'Most like my current unit', with each subsequent rank being assigned to the item next most 'Like my unit'. The item with a rank of 9 was considered by respondents to be 'Least like my current unit'.

To determine the extent to which respondents showed agreement (concordance) over the rank order of the safety culture items, Kendall's coefficient of concordance (*W*) was calculated (Gisev, Bell & Chen, 2013) for each of the three ranking/sorting methods according to the formula:

$$W = \frac{12S}{M^3(N^3 - N)}$$

Where S=Sum of squares of rank sums; M=number of respondents; N= number of items in set.

Kendall's coefficient of concordance (*W*) scores vary between 0 (no agreement) and 1 (complete agreement), and it was noted that with large numbers of raters even low *W* values can be significant (Gisev et al., 2013). There is no commonly accepted means of interpreting *W* values, however they can be interpreted in a similar way to kappa values (Landis & Koch, 1977, Table 18). Others have suggested that *W* values of less than 0.5 should be considered moderate to low, while values of greater than 0.5 indicate good concordance (Gearhart, Booth, Sedivec & Schauer, 2013).

Table 18.

Interpretation of kappa values, drawn from Landis and Koch (1977).

Value	Interpretation
<0.00	Poor
0.00-0.20	Slight
0.21-0.40	Fair
0.41-0.60	Moderate
0.61-0.80	Substantial
0.81-1.00	Almost perfect

The different statistical techniques to which each of the ranking/sorting methods were amenable is summarised in Table 19.

Table 19.

Summary of statistical treatments applicable to the three ranking methods.

Statistical treatment	Method	Applicable	Result
Calculation of Between Respondent Concordance (*W*)	Direct ranking	✓	0 indicates no agreement, 1 indicates complete agreement between respondents.
	Q-Sort	✓	
	Paired comparisons	✓	
Within Respondent Consistency (k)	Direct ranking	x	0 indicates completely inconsistent, 1 indicates completely consistent. Threshold of 0.7.
	Q-Sort	x	
	Paired comparisons	✓	
Item scaling	Direct ranking	x	Ordinal scale
	Q-Sort	x	Ordinal scale
	Paired comparisons	✓	Interval scale

Analysis of Workload Measures - NASA-TLX

To determine the presence of inter-method differences in workload the Friedman test was used on results from the six NASA-TLX sub-scales. This non-parametric statistic is used with repeated measures on ordinal data and identifies differences between groups (Field, 2009).

5.3 Results

5.3.1 Between Respondent Concordance (*W*)

Between respondent concordance (W) was calculated to consider the extent to which respondents showed agreement over the rank order attributed to the nine safety statements. The results from this analysis for the three methods is shown in Table 20, with the Chi^2 value used to test for significance (Ferguson, 1981).

Table 20.

Co-efficient of concordance (W) for all response sets (N=37).

Method	Co-efficient of concordance (*W*)	Chi^2 value	Significance
Direct ranking	0.271	80.216	0.0001
Q-Sort	0.256	75.704	0.0001
Paired comparison	0.325	96.000	0.0001

Results showed that that overall agreement for the three ranking/sorting methods was statistically significant (p<0.01). When compared to the criterion in Table 20, this agreement would be labelled as *fair* while when interpreted against Gearhart et al.'s (2013) criterion, each *W* was less than 0.5, and so could be considered to show moderate to low concordance. The highest agreement was observed for the method of paired comparisons (*W*=0.325), the direct ranking method showed the next highest level of agreement (*W*=0.271) whilst the Q-Sort method showed the lowest level of agreement (*W*=0.256).

5.3.2 Exploration of Sub-Population Concordance

Several authors have reported differences in views on safety between personnel of varying managerial levels (Lee, 1996; Weyman & Clarke, 2003) and occupational groups (Fleming, Flin, Means & Gordon, 1998; Rundmo, 1992, 1996). It was of interest to explore whether agreement as to the rank order of the safety dimensions varied by sub-group within the current sample group, i.e. whether some groups showed higher levels of concordance than others. The demographic data gathered in this study permitted identification of sub-samples for function (aircrew and engineers) and rank (junior and senior engineers). The homogenous nature of Aircrew ranks meant that this cadre could not be meaningfully separated by rank.

The co-efficient of concordance (*W*) was calculated for each of the sub-groups. When compared by function, agreement within the aircrew and engineer groups (Table 21) generally showed *moderate*, statistically significant concordance. Most were lower than the 0.5 threshold set by Gearhart et al. (2013), other than for the paired comparison method for aircrew respondents (*W*=0.503). Particularly low concordance was noted for the method of paired comparison within the engineer sub-population (*W*=0.265).

Table 21.

Co-efficient of concordance for Aircrew (N=15) and Engineers (N=22).

Function	Method	Co-efficient of concordance (*W*)	*Chi*^{2} value	Significance
Aircrew	Q-Sort	0.461	55.312	0.0001
	Direct ranking	0.407	48.89	0.0001
	Paired comparison	0.503	60.305	0.0001
Engineers	Q-Sort	0.461	55.312	0.0001
	Direct ranking	0.407	48.89	0.0001
	Paired comparison	0.265	46.705	0.001

When separated by rank (see Table 22 for comparison between junior and senior engineers), agreement amongst junior engineers was particularly low for all three ranking/sorting methods (ranging between *W*=0.139 and 0.196), and was generally non-significant. In contrast, concordance between senior engineers was higher, all being statistically significant, with one result over the threshold set by Gearhart et al. (2013) for good concordance (paired comparison method). Although only exploratory, these findings tentatively indicate that there might be less agreement regarding the rank order of safety dimensions between junior engineers than the other sub groups.

Table 22.

Co-efficient of concordance for junior engineers (11 respondents) and senior engineers (11 respondents).

Rank	Method	Co-efficient of concordance (W)	Chi^2 value	Significance
	Q-Sort	0.196	17.270	0.027
Junior	Direct ranking	0.139	12.194	0.143
	Paired comparison	0.145	12.717	0.122
	Q-Sort	0.344	30.316	0.0001
Senior	Direct ranking	0.406	35.758	0.0001
	Paired comparison	0.549	48.305	0.0001

5.3.3 Comparison of Rank Order Across the Methods

The statistically significant between-respondent concordance over the rank position of the safety dimensions within each of the three ranking methods is suggestive of shared views on the ordinal salience of the safety dimensions. Therefore, it was considered appropriate to further explore the rank order for each method in relation to the criterion of how much 'Like my unit' each of the dimensions were ranked. To formally test the degree of agreement on the level of rank order, a Friedman's test was applied. The results (Table 23) indicated that there was no significant difference between the three methods with regards to rank order. This would indicate that the three methods provide an essentially equivalent rank order.

Table 23.

Friedman's test statistics between aggregated rank order position of the safety climate dimensions across the three ranking methods.

Method	Mean Rank	Chi^2	Significance (p)
Q-Sort	1.89		
Direct ranking	1.89	1.333	0.513
Paired comparisons	2.22		

When the mean rank orders of the safety culture/climate dimensions were compared across the three methods (Table 24), a number of similarities were apparent. Firstly, *individual actions* (Everyone accepts that flight safety is their responsibility) was ranked highest in all three methods, indicating that this was 'Most like my unit'. This may be interpreted as a high degree of personal responsibility for safety being particularly salient amongst this sample as a positive feature of their workplace. Similarly, *human resources* (There are enough people to do the job safely) was consistently ranked lowest, indicating that respondents perceived this to be 'Least like my unit'. Thus, it would appear that the most saliently negative issue related to safety amongst these respondents was the fact that they perceived a shortfall in the amount of personnel who were available. This might indicate an area of concern for the respondents, and therefore may be interpreted as a priority. The consistent ranking of these two items at the extremes of the rank orders suggests that these are the most obvious to respondents, and therefore potentially have high salience.

Table 24.

Comparison of mean rank order of the nine safety climate dimensions for alternative ranking methods.

Rank order	Q-Sort	Direct ranking	Paired comparisons
1	Individual actions	Individual actions	Individual actions
2	Safety training	Safety training	Safety training
3	Working environment	Safety system	Working environment
4	Management commitment	Management commitment	Management commitment
5	Safety system	Working environment	Safety system
6	Communication	Communication	Communication
7	Priority of safety	Priority of safety	Competency/experience
8	Competency/experience	Competency/ experience	Priority of safety
9	Human resources	Human resources	Human resources

Note: 1= most like my unit and 9 = least like my unit.

Safety training (Flight safety training is an integral part of all routine training) was ranked as second 'Most like my unit' across all three ranking/sorting methods, suggesting that respondents perceived the organisation as effectively managing safety training in relation to the other areas of safety climate. Two other dimensions received consistent rank orders across the three methods, with *management commitment* (Individuals are empowered by their management to take actions in the interests of flight safety) being ranked fourth, and *communication* (Occurrences that have flight safety implications are consistently followed up) ranked sixth out of nine dimensions. Whilst there is consistency, the positions of these dimensions in the middle third of the rank orders may suggest that these are perhaps less salient than some of the other statements.

Of further interest are the two dimensions of *priority of safety* (People do not take flight safety risks, even when work demands are high) and *competence/experience* (People here are sufficiently competent and experienced to do the jobs they are required to do safely) which were ranked seventh and eighth out of nine. Although there was not complete consensus across the methods, it would appear that there might be areas of concern in the levels of competency/experience of personnel and the negative effect of work demands on safety behaviour amongst the military aviation respondents.

5.3.4 Subjective Workload Measures

The NASA-TLX scales were utilised to determine the subjective workload imposed by the three ranking/sorting methods. Each of the six scales, shown in Table 25, have values ranging from 0 to 100, with 0 indicating either low demand/effort/frustration or good performance and 100 indicating high demand/effort/frustration or poor performance. In general, the ranking/sorting methods were rated as below 50% for all scales, indicating that the methods were relatively benign in terms of the perceived workload imposed. The physical and temporal demands of the task were rated as particularly low across all three ranking/sorting methods.

Table 25.

Freidman's statistical test results for the NASA- TLX sub-scales.

NASA-TLX subscale	Method	Mean (SD)	Mean rank	*Chi*^{2}	Significance (*p*)
Mental demand	Direct Ranking	34 (20)	1.97		
	Q-Sort	34 (23)	2.04	0.110	0.946
	Paired Comparison	30 (18)	1.99		
Physical demands	Direct Ranking	8 (5)	1.89		
	Q-Sort	9 (6)	2.07	1.690	0.430
	Paired Comparison	8 (5)	2.04		
Temporal demands	Direct Ranking	16 (12)	1.95		
	Q-Sort	16 (15)	1.86	3.120	0.210
	Paired Comparison	19 (15)	2.19		
Performance success	Direct Ranking	31 (19)	2.14		
	Q-Sort	28 (18)	1.89	1.541	0.463
	Paired Comparison	30 (18)	1.97		
Effort	Direct Ranking	28 (20)	1.93		
	Q-Sort	29 (19)	2.07	0.417	0.812
	Paired Comparison	26 (18)	2.00		
Frustration	Direct Ranking	19 (19)	1.85		
	Q-Sort	16 (13)	1.80	9.376	0.009
	Paired Comparison	27 (24)	2.35		

Where SD= standard deviation

The majority of the NASA-TLX sub-scales showed no significant difference between ratings attributed to the three methods, with the exception being 'Frustration'. On this scale respondents rated the paired comparison method as significantly more frustrating to complete (p<0.01) compared to the remaining two methods. The method of paired comparisons requires respondents to compare each item with every other item individually, and so it is likely that this frustration arose from either the repetitiveness of the method, or the length of the exercise (there were 36 pairs of items to compare).

5.3.5 Respondent De-brief

Respondents were asked to provide feedback about the ranking exercises in a written de-brief. When asked 'Did you understand what you were required to do for the ranking exercise?', all respondents indicated in the affirmative, suggesting that there were no difficulties with understanding how to complete the exercises. When asked to detail any specific experiences that they may have used when deciding how to rank the safety dimensions on each of the exercises, seven respondents provided feedback. Of these, five indicated that no specific instances were used (indicative examples of feedback include "*No particular instances come to mind, I merely used the day to day routine of squadron life in my answers"* and *"Just examples I have seen on squadron and how they are challenged and dealt with"*). Two individuals suggested that the lack of available people and experienced personnel were experiences that they used, highlighting that this was usually due to detachments (i.e. travelling away with a ship) or other duties.

When asked to detail any further areas which they felt were applicable to flight safety which had not been captured in the nine safety dimensions, eight respondents provided answers. Here, four suggested that an item on the availability and suitability of equipment (including survival equipment) was required. Two respondents highlighted fatigue, one suggested human factors and one suggested an item relating to whether people feel rushed when completing jobs.

5.3.6 Summary of Findings

The purpose of this study was to characterise employee perspectives on the primacy of headline influences on safety in the FAA through comparing and corroborating findings from three widely used comparative ranking methods. The findings showed that there was broadly statistically significant, *fair* agreement amongst personnel regarding the rank order to which nine safety related statements were ascribed as being 'most' or 'least' like the respondents' units.

The three methods (Q-Sort, direct ranking and the method of paired comparisons) produced statistically similar aggregated rank orders of the nine statements). These findings somewhat contrast with previous assertions that the choice of ranking elicitation technique can strongly affect ranking outcomes (Ali & Ronaldson, 2012; Fisher et al., 1968; Mullen, 1999; van den Fels-Klerx et al., 2017), as this did not appear to be the case in the current study.

The dimension *individual actions* (Everyone accepts that flight safety is their responsibility) was consistently ranked as being ’Most like my unit'. In contrast, *human resources* (There are enough people to do the job safely) was consistently ranked as 'Least like my unit'. *Priority of safety* (People do not take flight safety risks, even when work demands are high) and *competency/experience* (People here are sufficiently competent and experienced to do the jobs they are required to do safely) were ranked relatively negatively. On the whole, there were no significant differences in subjective workload between the three ranking methods, however respondents found the method of paired comparisons significantly more frustrating to complete than either the direct rank ordering or Q-Sort methods.

5.4 Discussion

The study revealed that military aviation respondents could make consistent discriminations between nine dimensions which were considered to influence safety and risk decision making when using three ranking techniques (Q-Sorting, direct ranking and the method of paired comparisons). This would suggest that the dimensions were meaningful to the respondents. The level of agreement between respondents about the rank order of the safety statements was low to moderate, with no clear evidence that any one method displayed better agreement than the other two. This corroboration between different methods might suggest that confidence in the aggregated rank order of the safety dimensions is reasonably high.

5.4.1 Comparison of Ranking Methods

In light of existing concerns regarding observations that the method of ranking can be shown to affect responses it was noteworthy that the current study showed no significant effect on the overall rank order in which nine safety dimensions were placed by the respondents. This would suggest that there was little to differentiate the three methods when using them to prioritise dimensions for safety improvements, where the objective was to derive a simple ordinal ranking.

Strengths, Limitations and Performance of the Ranking/Sorting Methods

Given the similarities in rank orders ascribed by each method, it could be argued that any of the three methods could be used by the FAA to gain an understanding of how their personnel view aspects of safety in their workplaces, and where improvements may best be targeted. However, each of the Q-Sort, direct ranking and method of paired comparisons have acknowledged strengths and limitations, and the ways in which these manifested in the current study are briefly discussed below in relation to their utility for FAA purposes.

Q-Sort

The FAA Flight Safety Q-Sort originally contained twenty-one items to sort. However, this number of (largely redundant) items have previously been suggested as a potential source of confusion amongst respondents (Ashford, 2016) and so for the purposes of the current study the complexity of the tool was reduced by limiting the number of items to be sorted to reflect the smaller number of underlying dimensions (see Table 1, Appendix C). This also allowed a more direct comparison of the Q-Sort method with the other methods (direct ranking, method of paired comparisons).

No concerns were raised by respondents about understanding how to apply the Q-Sort method and findings from the NASA-TLX showed that the perceived workload of the method was considered relatively low. It was noted, however, that one data set had to be removed from the analysis due to a respondent not conforming with the forced distribution answer grid. This may have resulted from an incomplete understanding of the instructions, or that the respondent was unwilling/unable to rank the safety dimensions according to this distribution.

Q-Sort ranking allowed the respondents to rank items which they perceived to be similar at the same rank (Eyvindson et al., 2015), within the bounds of the forced distribution where fewer statements were placed at the extremes, and more in the neutral/middle of the ranks. It is possible to use a free distribution with Q-Sorting, such that participants can place any number of items at any place along the continuum. However forced sorting is held to have the advantage that as items assigned to the middle (neutral) categories tend to be considered relatively less important, yet require discriminations that raters can find difficult, maximising the number of items in the middle reduces the difficulty faced by respondents (Block, 1978). Nevertheless, this method may also force respondents to make discriminations they otherwise would not make between items.

Data collection for the Q-Sort method was relatively simple and economical, with respondents often completing the exercise in approximately fifteen minutes. This method was amenable to statistical calculation of between-person agreement, which indicates the degree of 'shared' views, however only ordinal ranks could be furnished using the Q-sort method, such that no comment could be made regarding the relative difference between categories, other than directionally (higher/lower, more/less positive).

Direct Ranking

Like the Q-Sort method, respondents typically perceived the direct ranking method to impose low workload and reported no difficulties with completion. One response set had to be removed as the individual had placed several items in a 'tied' fashion; possibly indicating a preference to rank several items at a similar level. This tentatively supported criticisms that this method may force people to make unrealistic discriminations between items (Eyvindson et al., 2015). The method did appear simplistic to apply, with straightforward written instructions which were easy to devise, and economical data collection. The suggested efficiency of the method (Curcin, Black & Bramley, 2009) was borne out in the time taken to complete; although not specifically measured, individuals completing the direct ranking task were observed to complete the exercise relatively quickly, typically in under approximately ten minutes. Direct ranking has been criticised for low reproducibility (i.e. test-retest reliability); although this was not tested in the current study, the high concordance with Q-Sort and paired comparison rank orders might tentatively suggest that this may not be an issue for the item set used in this study

Direct ranking is amenable to statistical calculation of between-person agreement, which indicates the degree of 'shared' views. However, like the Q-Sort method, although the rank order of dimensions obtained using this method afforded ordinal rankings, this did not allow calculation of the relative distance between the items (Droba, 1932; Scheibe et al., 2002) and so was not able to consider if any of the items stood out from the others (Susel et al., 2016). Thus, limited inference could be made about the relative position of each dimension in the rank order other than directionally (higher/lower, more/less positive).

Paired Comparisons

While all three ranking methods allowed consideration of the degree to which a 'shared' view was held, only the method of paired comparisons was also amenable to calculation of intra-rater consistency. This allowed for comment on the ability of respondents to *meaningfully* discriminate between the items/statements to be made, as a higher number of triadic relationships are often observed to occur within data when the items being compared are too similar (Brown & Peterson, 2009). The fact that 92% of respondents showed acceptable intra-rater consistency suggests that the safety dimensions utilised in this study were discernible concepts to respondents.

While the direct ranking and Q-Sort methods are limited to producing an ordinal ranking, the method of paired comparisons is designed to produce an interval scale. An advantage of this is that it afforded additional insight with respect to the 'distance' on a continuum between one item and the next. There was no *a priori* item chosen to anchor the interval scale in the current study and so consideration was given to the rankings shown in Table 24. The statement relating to *human resources* was consistently the lowest ranked dimension. The interval scale was therefore calibrated to this item by setting the statement related to *human resources* as zero, and transforming the values of the other items in relation to this, by calculating their relative distance from the *human resources* statement (following methods described by Cromer et al., 1984). This resulted in the distribution of the safety dimensions on the scale demonstrated in Figure 4.

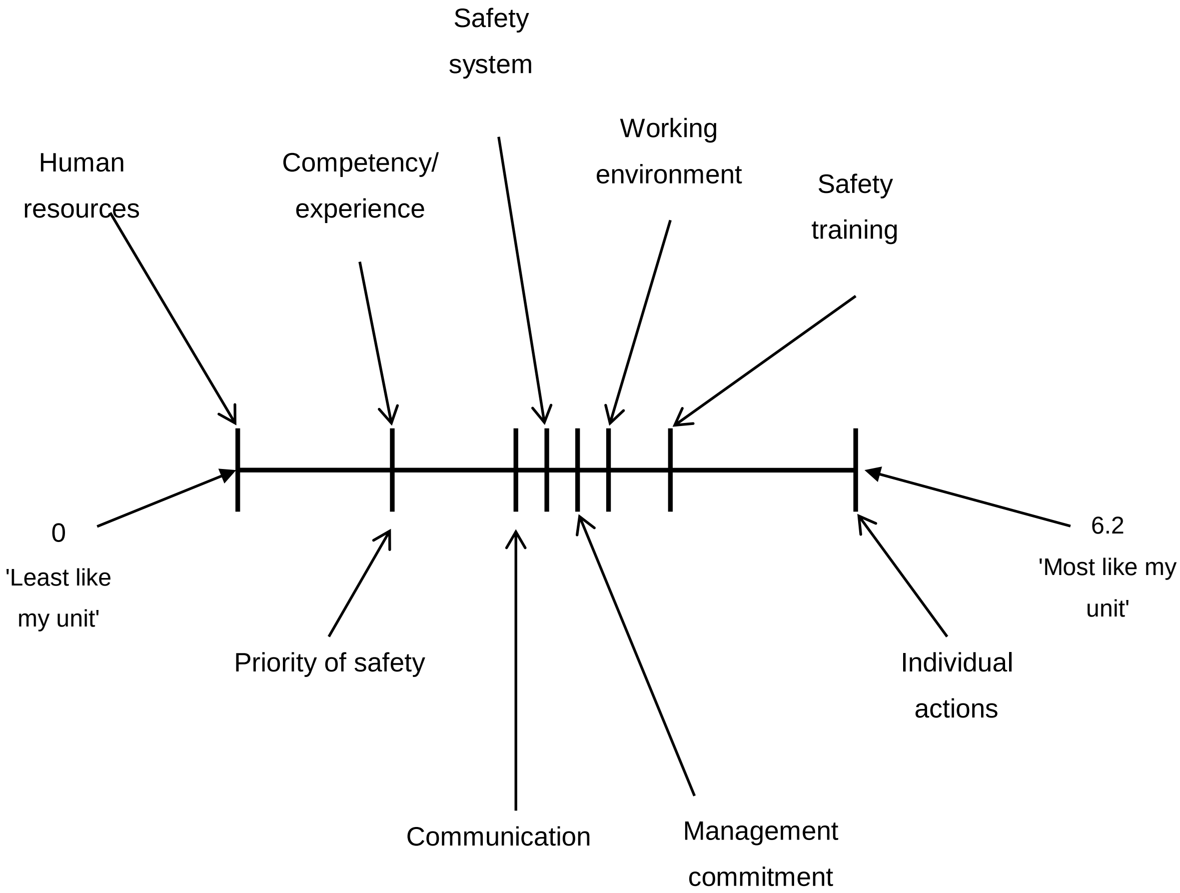

Figure 4. Representation of interval scale indicating the relative position of safety items in relation to 'Least like my unit' (0) and 'Most like my unit' (6.2) for all respondents.

Relative to the lowest ranked dimension (*human resources*), *individual actions* (Everyone accepts that flight safety is their responsibility) was ranked at the opposite end of the interval scale (with a scale rating of 6.2). *Competency/experience* (People here are sufficiently competent and experienced to do the jobs they are required to do safely) and *priority of safety* (People do not take flight safety risks, even when work demands are high) were clustered toward the lower end of the scale (with a scale rating of 1.5). The remainder of the items (*Communication, safety system, management commitment, work environment* and *safety training)* clustered together toward the mid-point of the scale, with little differentiation between them. Interestingly, Anselmi, Fabbris, Martini and Robusto (2018) found that this method tended to be most reliable at the highest and lowest ranks, and less so in middle ranked items. These authors postulated that respondents found it easy to identify the extreme ranked items, but that the middle items required more effort to rank, and therefore were more unreliable.

The method of paired comparisons therefore had the advantage of providing deeper insight into the relative salience of the items when compared to the Q-Sort or direct ranking methods. In relation to using this method to inform safety managers, therefore, it may provide a more nuanced understanding of the degree to which certain items are different to the others. This could therefore be used to infer what issues may best be addressed to improve safety. Similar conclusions regarding differentiation regarding relative positions of items were noted by Anselmi et al. (2018).

However, the administrative burden of the method of paired comparisons lay in the number of comparisons which were required (36 in this study) which increased the time requirement (often taking the whole allocated thirty minutes to complete), and booklet size. These findings were in line with those demonstrated by Aloysius et al. (2006) who indicated that the method of paired comparisons generated decisional conflicts, were more effortful and less desirable to use than other methods. Arguably, this is likely to be the reason that this method was considered by respondents to be the most 'frustrating' of the methods. Furthermore, the number of potential items that could be ranked using this method was limited (without the added complexity of an incomplete design) to a maximum of nine entities (Chalwa & Sodhi, 2011; Ock et al., 2016; Weyman et al., 2006). While an incomplete design was an option, it would have had the disadvantage of increasing the required sample size. Therefore, this method was appropriate for ranking the nine safety dimensions, but would arguably not be suitable for ranking the original twenty-one items from the FAA Flight Safety Q-Sort.

Summary

Although the final order of ranking did not appear to be affected by the method of ranking used (when comparing three widely used alternative methods), the method of paired comparisons had several advantages over the Q-Sort and direct ranking methods. The results from the method of paired comparisons afforded a more nuanced insight into the relative priority given to the influences of safety. The most noticeable of these was the interval scale generated using the method of paired comparisons (see Figure 4) which allowed consideration of the relative distance of the dimensions from each other as well as stand-out items, and those items which showed little discrimination from each other. However, the Q-Sort and direct ranking methods were significantly less 'frustrating' for respondents to complete, required a lower time burden on respondents, and were simpler to administer during data collection.

Comparison of concordance of individual and aggregated rank order

Although not a primary aim of the study, in light of the modest concordance of aggregated rank order (detailed in Table 20) an exploratory analysis of the concordance of rank order at the individual level was undertaken. Results from this analysis (Friedman's test of rank order, Table 4 in Appendix C) showed that unlike the aggregated rank order, at the individual level significant differences ($p<0.05$) were seen between the three ranking methods for all nine safety dimensions. Post hoc tests (Wilcoxon's test with Bonferonni adjustment) revealed that these significant differences occurred between the Q-Sort and both the direct ranking method and method of paired comparisons. However, no significant differences were seen between the direct ranking method and method of paired comparisons. The only exception to this was the dimension of *individual responsibility* which showed no significant differences in rank order between all three ranking methods.

These findings raised two issues worthy of discussion. Firstly, the findings corroborated the previous assertion that *individual responsibility* was the dimension on which military naval aviation personnel showed strong agreement on, ranking it as 'most like' the situation in their units. Secondly, the lack of concordance between ranking methods at the individual level, in contrast to the significant agreement shown at the aggregated rank order level, raises questions regarding whether the group ranking is representative for each method. This is similar to the criticisms levelled at the aggregation of rating scales (Russell & Gray, 1994), and requires consideration in future studies.

5.4.2 Utility of Ranking Methods: Role and Contribution to Risk Management

Sound risk ranking is essential to efficient safety management (Fischhoff & Morgan, 2012). To determine prioritisation of safety dimensions for safety improvement, the findings from this study interpreted as dimensions of concern those seen to be least evident in the workplace. Whilst it is acknowledged that this is an assumption, both the previous qualitative study (Chapter 4) and a review of the literature (Chapter 2) would indicate that each of the dimensions could reasonably be expected to be evidenced in a workplace in which safety was considered important. Therefore, by inference, if respondents showed agreement as to which dimensions may be 'least like' what they observed in their workplace, this might indicate areas in which the organisation should target their resources to effect safety improvements.

With respect to the rank order of influences on safety, having sufficient personnel available (*human resources*) was consistently the most negatively ranked dimension. In contrast, observation that individuals accepting that flight safety was an *individual responsibility*, was consistently ranked the most likely dimension to be observed in the workplace. These findings plausibly suggest that respondents can consistently identify which safety influence is displayed most and least noticeably within their units and that it may be easiest to identify the extremes of the ranks (i.e. the best and worst aspects of workplace safety).

Two further dimensions, *priority of safety* and *competency/experience,* were typically ranked in seventh and eighth position out of nine, with high agreement as to the position of these dimensions. Arguably, these influences on safety are likely to be particularly salient to participants. However, the ranking of the remainder of the safety dimensions (*safety training*, *management commitment, communication, working environment* and *safety system*) appeared to vary to a greater degree between individuals. These findings reflect alignment with Anselmi et al. (2018) who suggested that ranking methods (particularly the direct ranking method) tended to show the highest reliability at the top and bottom positions of the rank order, with greater variability in the middle ranks. Exploration of the paired comparison data further corroborates these findings, as the dimensions of *individual responsibility, human resources, priority of safety* and *competency/experience* were stand out items (see Figure 4) while others (*safety training*, *management commitment, communication, working environment* and *safety system*) appeared to 'cluster' together toward the middle of the interval scale, and therefore showed less discrimination from each other.

Taken together, and interpreted from the viewpoint of organisational prioritisation, the findings from the study suggest that there were a small number of dimensions which may be particularly salient to military aviation personnel, and thus require prioritisation by the FAA. Priorities for improvement may therefore lie in addressing issues of availability of *human resources*, *work pressure* and *competency/experience*. This analysis did not determine what the effects of these dimensions being less evident in the workplace were likely to be, but may provide direction for further investigation in the future.

In contrast, military aviation employees viewed their colleagues as having a high degree of *individual responsibility* for safety. The fact that some dimensions (*safety system, communication, working environment* and *management commitment*) showed little discrimination and variable aggregated rank order would indicate that there might be little utility in prioritising these for safety improvement, as these appeared to show less agreement, and therefore might vary more widely across workplaces. These findings should, however, be interpreted in light of the limited sample size (37 respondents) and limited workplace variation (only two locations were sampled), such that the generalisability of these findings to the wider FAA population is unknown.

The current findings can be almost directly contrasted with those reported by Biggs, Banks, Davey and Freeman (2013) where employees in a construction firm were shown to have ranked aspects of individual responsibility for safety as least evident, and the organisation ranked as having a clear responsibility for safety. These differences may perhaps highlight the importance of interpreting results with an understanding of the respondent sample. In the case of the current study, frontline military aviation personnel were used, while Biggs et al. (2013) used a sample of safety leaders. Each group may, arguably, have provided responses which are self-serving. In the current study, the dimension *individual responsibility* is perhaps the only one over which frontline individuals have control, while they have little control over aspects such as *human resources*, *priority of safety* and *competence/experience.* In contrast, Biggs et al.'s (2013) sample of senior managers may have preferred to blame poorer safety standards on frontline personnel, and consider the organisation to be more committed to safety than frontline staff might. To determine whether this was indeed the case, the current study could be repeated, with the sample group being comprised of senior safety managers, and the results then compared with the current findings.

5.4.3 Concordance Between Individuals and Groups of Personnel

Between-respondent agreement across the sample was found to be *fair*; when functional demographic groups were considered separately, however this agreement generally showed increased levels when sub-groups were considered separately. This was found to be the case for aircrew and senior engineers who displayed higher levels of agreement than did the group of junior engineers. Although issues of restricted sample size are acknowledged, these findings would tentatively support previous assertions that perceptions of factors affecting safety were prone to vary by functional and hierarchical groups within organisations (in line with Fleming, Flin, Means & Gordon, 1998; Lee, 1996; Rundmo, 1992, 1996; Weyman & Clarke, 2003).

Unlike aircrew and senior engineers, junior engineers showed relatively low levels of concordance regarding the rank order of dimensions within their group. It could be that the groups of junior engineers lacked shared experience due to fewer years of working together than the other groups. These individuals may simply not have had sufficient time working together to create a shared view on the safety items. Similar findings have been reported by Nordlof et al. (2012) who suggested that agreement regarding safety priorities was higher between counterpart managers in different organisations than between managers and safety delegates from the same organisation. These authors reported that managers consistently ranked prioritisation of the work environment higher than did safety delegates, potentially reflecting that managers may have been more optimistic about improvements in safety climate than employees (Forth, Bewley & Bryson, 2006). These varying perceptions between employees within a single organisation may also reflected their different roles and frameworks which they used to interpret the work environment (Lave & Wenger, 2003).

5.4.4 Limitations/Future Research

The findings from this study provided insight into employee perspectives on safety standards in their workplace. The discriminant criterion for the ranking was the degree to which each safety dimension was 'like' or 'not like' the respondents' units. Those ranked as being 'least' observed in the workplace were assumed to reflect behaviours/dimensions that could require prioritisation for improvement.

However, it was acknowledged that the discriminant criterion against which the dimensions were ranked would likely have a large impact on the priority order in which the items were placed. The study did not consider the *importance* which personnel attributed to the different dimensions, and therefore assumed a degree of equivalence in the contribution of each toward safety. Some degree of importance may be inferred from the rankings in that, for example, the high concordance that sufficient available people were not considered as evident may reflect the importance with which this dimension is accorded (respondents agreed and ranked this item as a stand-alone negative item). However, this assumption would benefit from further empirical testing regarding the level of importance the respondents ascribe these dimensions. This may perhaps be achieved by using an alternative discriminant criterion of '*most important in supporting safe behaviour'* to *'least important in supporting safe behaviour'* within the unit.

The sample did not include senior management ranks; it might therefore be of interest to investigate and compare how senior naval aviation staff view the degree to which these safety dimensions are evident in their units, and consider how similar or different this may be to the views of the frontline personnel. The study did not consider the test-retest reliability of the three ranking methods; however this would be important prior to introducing any of these methods for further data gathering. Although each data collection session was separated by at least four hours, it is possible that respondents were able to recall the rank order used in previous data collection sessions. It may have been more robust to complete data collection once per day for three days, however this was not acceptable to the squadron management who facilitated access to respondents for the study.

5.5 Conclusions

The aims of this study were to elicit FAA personnel views on priorities for safety culture / climate enhancement, and to compare the performance of alternative elicitation techniques in terms of the rank order produced, their ease of use and their potential contribution to informing senior decision making over setting priorities for improvement.

To address the first aim, a set of nine dimensions of safety climate / culture were identified on the basis of findings from the literature review (Chapter 2), the qualitative findings from Study 1, and the extant climate element prioritisation tool used within the FAA. These dimensions were considered to characterise core influences on safety and were each represented by a suitable brief descriptor. The nine safety influences appeared to be meaningful to military aviation personnel in that they could make stable and consistent distinctions between them. These were therefore considered important dimensions to consider for inclusion in a safety climate tool for this population (Studies 3 and 4).

The second objective was to compare the product of three alternative ranking methods. Findings revealed that:

- Each produced a statistically significant degree of *agreement* (concordance) across raters regarding the order of importance.
- No statistically significant differences between Q-Sort, method of paired comparisons or direct ranking were detected at the level of rank order.

The final objective (to provide comment on the utility of safety issue priority ranking with respect to its potential role and contribution to risk management) was met through the finding that there was high agreement over priorities for improvement:

- Staffing levels: Respondents ranked the phrase 'There are enough people to do the job safely' to be 'least like' the unit.

- The dimensions of *priority of safety* (People do not take flight safety risks, even when the work demands are high) and *competency/experience* (People here are sufficiently competent and experienced to do the jobs they are required to do safely) were ranked second and third in most need of attention and improvement.

The findings highlighted *human resources* (staffing levels), *priority of safety* and *competency/experience* as areas of safety management that employees consider should be priorities for intervention and improvement.

Future research might seek to build on these findings by exploring not only what employees perceive as their current situation, but additionally whether there is agreement as to which of these dimensions is the most *important* in developing and maintaining a safe military naval aviation working environment. Future research might also seek to conduct a similar study amongst senior management may indicate whether the views articulated in this study are shared by more senior staff, or not.

Chapter 6: Quantitative Exploration of Variables Impacting on Employee Perceptions of Safety Climate in Military Naval Aviation (Study 3)

6.1 Introduction

6.1.1 Purpose of the Project and Rationale

A core aim of this thesis was to explore and understand the basis for military aviation employee observations of behaviour in relation to safety and the contextual factors that might be most salient influences on this. The initial qualitative phase of the research (Study 1, Chapter 4) yielded rich, employee-driven insights with which to contextualise safety culture within the organisation. However, although well suited to exploring cultural elements, qualitative inquiry is inherently limited by the generalisability of the conclusions which can be drawn beyond the participant sample. Furthermore, it does not allow for creation of quantifiable safety profiles which may be used to assess change over time, support comparisons between different demographics or provide the organisation's safety managers with a means of systematically diagnosing areas for safety improvement. In the current economic climate, this is of increasing importance as resources are limited, requiring safety managers to prioritise where resources might best be allocated in order to improve or maintain safety within the organisation. Chapter 5 (Study 2) explored the utility of using three alternative comparative ranking techniques to gain insight into employee perceptions of safety priorities. Further research is required to develop these methods to ensure robustness, with the aim that they might be used as part of a 'toolkit' that the FAA could use to gain insight into employee perspectives of safety within the organisation.

Study 3 aimed to develop a quantitative measure of safety climate, complementary to the comparative ranking techniques trialled in Study 2, by using both the rich qualitative data obtained in Study 1, and findings from Study 2, to inform the development of a psychometrically robust safety climate tool. Methodologically, the study reflected alignment with contemporary safety culture/climate studies (notably Brondino, Pasini & DaSilva, 2013; Huang et al., 2013; Mearns et al., 2013), an approach which has yet to be taken by military safety culture/climate studies (discussed in Chapter 3).

6.1.2 Aim

To identify a finite set of components that can be considered to characterise headline influences on workplace safety climate amongst military aviation personnel.

6.1.3 Objectives

1. Based on the themes identified in Study 1 (Chapter 4), important safety factors highlighted in Study 2 (Chapter 5) and published findings (Chapter 2), develop a set of scalable items which will form the basis of a questionnaire suitable for self-completion by FAA personnel.

2. To explore the underlying factor structure of variables that characterise safety climate in a military naval aviation population.

3. Compare and contrast the derived factor structure with published findings in aviation and other, similar, industries.

4. Consider the scope and appropriateness of using the revealed component structure as the basis for developing a set of psychometric safety climate scales (undertaken in Study 4, Chapter 7).

6.1.4 Background

Normative quantification of workplace safety climate using organisation-level psychometric questionnaires has become a widely accepted technique for accessing employee perceptions of safety standards and conditions within their organisation (Harvey et al., 2002; Guldenmund, 2007). Safety climate has variously been described as an indicator of the underlying culture (Flin 2007; Guldenmund, 2000), a snapshot of employee perceptions (Guldenmund, 2007; Seo et al., 2004) and the structural/socio-technical context in which a safety culture persists (Olive, O'Conner & Mannan, 2006). In view of these descriptions, in this chapter, the term *safety climate* will be used in reference to quantitative, psychometric measures of perceptions about safety, whilst *safety culture* will be used in reference to deeper qualitative enquiries such as the approach taken in Study 1 (Chapter 4).

As was outlined in Chapter 2, while a small number of safety climate tools developed based on civilian populations have adopted grounded approaches, military safety climate tools have generally reflected the theoretically driven, top-down approach e.g. the CSAS and MCAS (Baker, 1998; Ciavarelli & Figlock, 1997) and the questionnaire developed for use in the ADF by Falconer (Falconer, 2006a). The current thesis therefore took a different approach to the two military aviation measures detailed above. Rather, the approach reflected alignment with more organic perspectives rooted in employee accounts, using qualitative insights as a foundation for developing a safety climate measurement tool rather than determining the important facets in an *a priori* fashion.

6.2 Method

6.2.1 Ethical Approval

Permission to undertake the study was granted by both MODREC (reference 648/MODREC/15) and the University of Bath (15-194).

6.2.2 Perspective and Approach

To support the aims and objectives of the study, a quantitative approach was utilised. This was designed to complement previous insights (Chapters 4 and 5), and consider the generalisability of these findings to a larger sample of military aviation participants. The method was developed following insights from established organisation-level psychometric study practice (Diaz, Cabrera & Isla, 1997; Evans et al., 2007; Glendon & Litherland, 2001; Mearns et al., 2013; Zohar, 1980). Reflecting conventions within the safety climate domain, an exploratory analysis was conducted on scaled responses to a questionnaire comprised of statements to which respondents were asked to indicate their degree of (dis)agreement.

6.2.3 Questionnaire Development

Based on the themes generated in Study 1, insights from Study 2, and taking into account previous literature, a large battery of items/statements was generated (N~100). To start the development process, the constructs from the thematic analysis were used as a basis for clustering items. Where possible, use of terminology and examples (direct quotes and paraphrases) given by employees (from Study 1) were used to develop items or modify existing items from the tool tested in Study 2 (Chapter 5) and in the wider literature (Chapter 2), to reflect a grounded approach to item development.

A referent shift approach was taken regarding item wording. That is, each statement required the respondent to focus on the general behaviour of others in the workplace, rather than focusing on their own individual behaviour. This necessitated the respondents considering perceptions which may be shared by those around them, rather than focusing on individual attitudes or behaviour. This approach deliberately reduced the scope for undesirable self-serving attribution bias and attempted to access the shared behaviour and attitudes that authors have suggested comprise the 'cultural' aspect (Kines et al., 2011). An example of this referent shift approach would be *'Operational demands mean sometimes <u>people here</u> have to take short cuts'* as compared to the self-referent question *'Operational demands mean sometimes <u>I</u> have to take short cuts'*. The order of presentation of the questions was randomised by item content in an effort to avoid order effects (Lavrakas, 2008; Oppenheim, 2000).

Item Format

Reflecting alignment with comparable measures in other domains, items were configured as statements and required respondents to rate their degree of agreement with each statement using a five-point Likert scale containing the semantic anchors of 'Strongly agree', 'Agree', 'Neither agree nor disagree', 'Disagree' and 'Strongly disagree'. The Likert scale has been shown empirically to produce distributions that allow it to be analysed as interval data (Carifilo, 1978) although this has been debated more recently (Guldenmund, 2007). This format tends to be familiar to respondents and is easy and quick to complete (Oppenheim, 2000).

Expert Appraisal and Cognitive Pilot

The original pool of items were further tailored to the military aviation context through discussion with a panel of experts with insight into managing safety and risks in military aviation (N=3). Terms which experts judged to be ambiguous, confusing or inappropriate for the context were revised or removed. For example, the designation *Senior management* was changed to *Squadron management*, *managers* was changed to *supervisors* and *demands* was changed to *operational demands*. Redundant items were removed to reduce the number of items to a more manageable total.

The item set were also further subjected to a cognitive pilot (N=8) with personnel drawn from a range of departments and ranks. The aim was to identify and resolve any drafting, semantic or sense making issues that required resolution e.g. irrelevant, redundant or otherwise difficult to understand questions. At the completion of the cognitive pilot, 78 items were retained for use (the full set of 78 items can be found in Appendix D), which fell within recommended limits to avoid poor response rates (Sudman & Bradburn, 1982). As participants were given time in work to participate in the study, operational concerns meant that data collection would need to be completed in a session lasting no longer than fifteen to twenty minutes, and piloting of these items showed that this timeframe could be achieved.

6.2.4 Procedure

Data collection was undertaken on three separate occasions between August 2015 and December 2015, at the two air stations which were the principle locations for the majority of personnel within the FAA. Given operational, technological and budgetary constraints, it was not possible to sample personnel who were operating from vessels at sea, those overseas, or those at smaller, geographically distant sites. Due to the variation in computer access experienced by military personnel, the potential for an on-line survey to introduce sample bias existed (lower ranks of personnel were less likely to have regular access to computing facilities than those of more senior rank). A traditional hard-copy (paper) administration of the survey was therefore adopted. Research with military participants completing the Armed Forces Continuous Attitude Survey utilising either email or posted questionnaires has typically achieved low response rates and thus in the interest of maximising response rates, a managed (manual distribution and collection) approach was applied.

Access to personnel was negotiated through the Chain of Command, initially by the project sponsor (the Flight Safety organisation), and then by the researcher. Information in the form of the participant information sheet (contained in Appendix D) was provided to potential participants through the regular establishment-wide weekly briefs and through advertisement on safety notice boards. This allowed widespread dissemination of information prior to the data collection visits which typically took place during scheduled safety stand-downs (allocated time given to departments exclusively to use for safety-related activity).

Potential participants were verbally briefed, with the researcher providing information regarding the informed consent process, study aims and requirements and assurances on confidentiality of results. Participants completed the informed consent forms (in Appendix D) and were then invited to complete the questionnaire (Appendix D). The researcher was available nearby to field any questions during completion time, which took approximately 15 to 20 minutes.

6.2.5 Sample

Participants were volunteers, drawn from an opportunity sample of military naval aviation personnel aged over 18 years. While not a stratified quota sample, the approach to recruitment aimed to capture an embracing array of demographics and aimed to avoid any notable structural imbalance.

There is limited agreement amongst researchers regarding sufficiency of sample sizes for principle components analysis, however a summary of available recommendations is contained in Table 26.

Table 26.

Summary of sufficient sample sizes for principle components analysis.

Author(s)	Recommendation
Everitt (1975)	Participant to variable ratio of 10:1
Nunnally (1978)	Participant to variable ratio of 10:1
Cattell (1978)	Participant to variable ratio of 6:1
Comrey (1978)	Minimum sample size of 200
Gorsuch (1983)	Participant to variable ratio of 5:1, minimum sample of 100
Kline (1986)	Minimum sample size of 200
Cohen (1992)	Minimum sample size of 393 to detect small to medium effects between two independent groups
Ferguson and Cox (1993)	Minimum sample size of 100
Hair et al. (1998)	Participant to variable ratio of 5:1, minimum of 100
Cooper and Phillips (2004)	Participant to variable ratio of 7:1

In light of these varying guidelines, it was calculated that for a battery of 78 items, a sample of approximately 450 respondents would produce a participant to variable ratio in excess of 5:1, meeting most of the recommendations from
Table 26. A sample size of ~ 450 also equated to approximately 10% of the overall population of the FAA.

In total, 462 questionnaires were completed; of these obtained response sets, pre-analysis checks (further detailed under Section 6.2.6) resulted in twenty-one data sets being removed due to missing data, excessive skew or kurtosis. This left a sample of 441 complete datasets for analysis (see Table 27 for demographic details of the sample used for the analysis).

Table 27.

Demographics of the sample after pre-analysis checks (N=441) on all response sets.

	Overall N=441
Aircrew	Junior ratings N=6
N=103	Senior ratings N=21
	Officers N=76
Engineers	Junior ratings N=198
N=284	Senior ratings N=79
	Officers N=7
Other*	Junior ratings N=32
N=54	Senior ratings N=12
	Officers N=10

Note. N=number of respondents. * Due to the small number of respondents, the 'Other' category was truncated to include Air Traffic Control and Support personnel. Demographics on male/female data was not collected due to the small number of female personnel in the FAA (<10%), leading to possible identification of respondents through demographic data.

The modest sample sizes from certain demographics, in part, reflect the structure of the organisation; aircrew tend to have a flatter hierarchical structure, with fewer personnel in junior ranks compared with engineers. By contrast the engineering branch conforms to the more traditional hierarchical military structure, with a large proportion of junior personnel compared to senior personnel.

6.2.6 Data Analysis

The analysis had two main objectives:

1. To explore and understand the component structure of a set of variables/components considered to characterise safety climate in this population.
2. To identify a suitable set of items on each of the variables/components to support further development of a tailored, empirically derived tool to measure safety climate (undertaken in Study 4, Chapter 7).

To achieve these objectives, selection of the most appropriate data analysis method involved comparing the merits of exploratory factor analysis (EFA) and principle components analysis (PCA). Both techniques are widely used when attempting to discover variables that form coherent sub-sets and display some independence to each other (Tabachnick & Fidell, 2014). These sub-sets (called factors or components) are thought to reflect some underlying process that creates correlations among variables. EFA and PCA are often used interchangeably, with both being exploratory techniques. In many cases, the difference between these techniques is seen to be small (Meyers, Gamst & Guarino, 2016; Thompson, 1992) however, theoretically PCA is conceptually simpler than EFA. PCA attempts to summarise sets of correlated variables (thus is considered empirical) while EFA is more theoretically complex as this method conceptualises factors as causes that underlie or drive the correlations (Meyers et al., 2016). The difference between these techniques is described as relating predominately to the variance that is analysed (Tabachnick & Fidell, 2014); in PCA all the variance in the observed variables is analysed, whereas in EFA only shared variance is analysed.

Where the primary aim of the data analysis method is to identify a smaller set of dimensions referenced to the common variance, PCA has been suggested to be the preferred method (Gorsuch, 1974; Stevens, 1992) and as such has been adopted by a number of safety culture/climate studies (Cheyne et al., 1998; Prussia et al., 2004; Yule et al., 2007; Keren et al., 2009; Huang et al., 2013). The method of PCA was therefore chosen as the most appropriate analysis method for the present study, with the analysis conducted using SPSS v22.

Method of Factor Rotation

To achieve a simple and parsimonious structure, an orthogonal (varimax) rotation was used under the assumption that the components would stand independently of each other (in line with Huang et al., 2013; Meyers et al., 2016). An orthogonal rotation supported the eventual aim of producing a set of scales on which to measure safety climate of the organisation. However, as the analysis was exploratory, an oblimin rotation was also conducted, to consider any differences in factor structure between the two rotation methods. Factors with an eigenvalue of one or greater were considered for retention (Ferguson & Cox, 1993), and the number of factors checked through use of a scree plot (Furr, 2011). This allowed the researcher to determine which factors best accounted for the most variance in the data, while retaining the most parsimonious solution.

Pre-analysis Checks

Before commencing the PCA, a number of pre-analysis checks were performed on the data (see Evans et al., 2007; Ferguson & Cox, 1993 for recommended procedures). Double data entry methods were used to conduct a random 10% check on data entry quality, with an observed error rate of 0.24%. The data was checked for missing values, and response sets with more than 10% of missing data were excluded from the analysis (as recommended by Evans et al., 2007). This resulted in removal of 12 data sets, leaving a sample of 450. Systematic bias in response missing data for each item was considered, however no patterns in the missing data were observed. A further nine participants were removed due to incomplete demographic data, leaving a sample of 441 for analysis.

An assumption of PCA is that variables conform to a normal distribution, thus requiring consideration of skewness and kurtosis of items (Ferguson & Cox, 1993). Any items with values of greater than 1 (or -1) were removed from further analysis. Detailed statistical analyses results are shown in Appendix D (removed items detailed in Table 1 of Appendix D are shown in bold). A summary of the items removed due to high skewness/kurtosis can be found in Table 28.

Table 28.

Items removed due to high skew or kurtosis.

Number	Item
Q1	People I work with think safety is very important
Q7	Generally, teams work well together in this organisation
Q16	People here fully understand the risks associated with the work that they are responsible for
Q17	Safety decisions are made at the appropriate level
Q22	People feel confident that they can question instructions when there may be safety issues
Q26	If someone reports a safety concern here, I am confident it will be addressed
Q30	Where I work hazards are appropriately assessed and controlled
Q36	People here are clear about what their responsibilities for safety are
Q38	Managers here would rather know about safety issues than not know
Q39	Where I work there is a Just Culture that ensures people are treated fairly
Q44	Managers are open to safety concerns raised by employees
Q45	My workplace identifies hazards and assesses risk
Q51	People here can easily identify the relevant safety procedure for their job
Q65	Most people are confident enough to speak up if they identify a safety issue
Q69	I am confident my line management will act in the interests of our team in terms of safety
Q72	Command here places appropriate focus on safety
Q73	People sometimes turn a blind eye to less important safety procedures

Omission of Low-correlating or Multi-collinear Items

Items which correlated weakly ($R<0.1$), or extremely ($R>0.9$) were considered for removal from analysis (Field, 2005), with only one item (Q21, 'I am regularly kept awake at night due to thinking about my job') being removed due to low correlation with any other items.

Assessment of the Appropriateness of the Data

To determine the appropriateness of the data set for PCA, the Kaiser-Meyer-Olkin (KMO) test for sampling adequacy and Bartlett's test of sphericity were conducted; results of these are shown in Table 29. The KMO was greater than 0.5 (Kaiser, 1974 in Field, 2005) and Bartlett's test was significant (Ferguson & Cox, 1993; Field, 2005), therefore signifying the appropriateness of the data for further analysis.

Table 29.

Results of KMO and Bartlett's test of sphericity statistics.

KMO Measure of Sampling Adequacy		.952
Bartlett's test of Sphericity	Approx Chi-square	11974.625
	df	1770
	Sig.	.0001

Partial Confirmatory Factor Analysis

On completion of the exploratory analysis, it was important to consider whether the model identified through PCA was viable for validity testing in the form of a confirmatory factor analysis (CFA). This was important because collecting data on a subsequent sample of participants would impose resource demands on the organisation, and as such it was prudent to consider whether this was likely to be purposeful. To support this, a PCFA was undertaken on the data gathered from the initial sample (Gignac, 2009). Several goodness of fit measures were calculated, including the root mean square error of approximation (RMSEA), Normed Fit Index (NFI), Tucker-Lewis Index (TLI), and the Comparative Fit Index (CFI) utilising formulae 1-4 contained in Appendix D (Bentler & Bonett, 1980; Bentler, 1990; Gignac, 2009; Tucker & Lewis, 1973).

6.3 Results

6.3.1 Principle Components Analysis

An initial PCA, based on eigenvalues of greater than 1, extracted 11 factors (see Appendix D, Table 2 for the total variance explained, Table 3 for the component matrix and Table 4 for the rotated solution), accounting for 57.3% of the total variance explained. The first component accounted for a total of 31% of the variance and contained 14 items. Three items were considered the minimum number required for retention of a component (Costello & Osborne, 2005; Raubenheimer, 2004) with five of the eleven components not meeting this threshold. Examination of the scree plot (Figure 1 of Appendix D) suggested that between five and nine components were present.

Results from the exploratory oblique (direct oblimin) rotation (Table 5, Appendix D), were compared with that of the orthogonal rotation (Table 4, Appendix D). While the oblique rotation returned an eleven-factor model, this rotation resulted in a factor structure which did not allow for interpretable factors, unlike the varimax rotation solution. As the objective of the

PCA was to derive a simple, interpretable factor structure, the varimax solution was adopted in this case (in line with recommendations made by Ferguson & Cox, 1993; Field, 2005).

Removal of low loading items

At this point, consideration was given to items with low loadings on the components. This was done to allow a 'cleaner' and more parsimonious factor structure to emerge. The sample size in the current study supported setting this threshold at $R<0.4$ (advocated by Field, 2005) and removed items are shown in Table 30.

Table 30.
Items removed due to low loading (R<0.4).

Number	Item
Q9	Operational safety has a high priority here
Q10	Supervisors/managers rarely check that people are working safely
Q12	People here are only interested in safety aspects of their own jobs, not other people's
Q14	There is timely feedback from the outcome of safety investigations
Q23	Safety will become less of a priority for Senior Leadership in the future
Q54	People have a clear understanding of the safety procedures for the job
Q55	When there is pressure people will not compromise on what they see as safety critical issues
Q61	The Senior leadership in the FAA mean it when they say safety is the highest priority

Treatment of Cross-loading Items

Items that loaded onto more than one factor (R>0.40) were considered on a case-by-case basis, with items judged for suitability by considering the face validity with the other items loading onto the factor. In these cases, the researcher determined which factor each item should be assigned to. These cross-loading items will be discussed under each component in the following sections.

To explore the latent components in relation to the theoretical concepts outlined in Chapter 2, the findings from the Studies 1 (Chapter 4) and 2 (Chapter 5), a series of forced solutions were completed on the data, informed by the results of the scree plot. These were conducted in an iterative manner to explore which might produce the most simple and parsimonious model, while retaining the maximum amount of explained variance. Here judgement was key to the process, interpretability and scientific utility was used to guide the process of the PCA (Tabachnick & Fidell, 2014). Thus, items were retained or removed based on a combination of knowledge of existing safety culture/climate theory and interpretability of factor loadings and factor structure returned by the forced solution PCAs.

Following a number of iterations, the final PCA solution comprised of six components, containing 41 items and accounting for 55.2 % of the explained variance, shown in Table 31 below (further details and the rotated solution can be found in Tables 6 and 7 of Appendix D).

Table 31.
Initial Eigenvalues and Rotation Sums of Squared loadings.

	Initial Eigenvalues			Rotation Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	13.97	34.07	34.07	5.94	14.48	14.48
2	2.29	5.58	39.65	5.33	12.99	27.47
3	2.13	5.20	44.85	3.60	8.78	36.24
4	1.70	4.15	48.99	2.76	6.74	42.98
5	1.37	3.33	52.33	2.59	6.33	49.31
6	1.16	2.83	55.16	2.40	5.85	55.16

Section 6.3.2 contains discussion of each of the components in Table 31 in turn, detailing the factor loadings of the items within each component and discussing how these compare and contrast with the existing safety culture/climate literature. To name the six constructs and identify their 'meaning', the content of the items that loaded onto each component were considered.

6.3.2 Naming and Interpretation of Constructs

Component 1: Management Commitment to Safety & Organisational Learning

Component 1 (Table 32) accounted for 14.5% of the variance, containing 14 items. When considering constituent items, these each related to perceptions of management behaviours in relation to safety. The items reflected employee perceptions of various levels of management, from supervisors and line management (close proximity to respondents), through to squadron management (more distant from respondents). Items also reflected management behaviours in encouraging safe work practices, listening to staff and being supportive in safety critical situations.

Table 32.

Items loading onto Component 1.

Number	Item	Loading
5	The Squadron Management encourages safe working practices	.660
4	Managers are willing to listen to staff when it comes to the best way to do something	.656
66	Line management looks out for us here	.647
20	Managers are quick to act on safety concerns when we report them	.639
28	The Squadron Management is good at finding the right balance between addressing safety concerns and the requirement to achieve a task	.607
78	There is poor communication about safety issues that may affect me	.606
29	My supervisor/manager encourages me and my team to learn from safety events	.596
64	If a genuine error is made (resulting in an accident or near miss), management will always be supportive	.593
25	Personal safety has a high priority here	.548
47	The squadron management here do a good job balancing operational requirements against safety	.541
35	Good safety behaviour is positively recognised by the line management here	.541
3	There is support from Management in safety critical situations	.485
27	People here are kept informed about the outcomes of meetings which address safety issues	.462
11	My supervisor/manager encourages questions from workers about safety matters	.461

While the overall focus within Component 1 was on management and its various safety functions, there appeared to be two sub-groupings of items. The first of these related to how management was perceived as taking care of safety, balancing priorities and looking out for its employees, shown in Table 33, and were interpreted as representing perceptions of management's commitment to safety. When compared to findings reported in Chapter 4, the items in Table 33 mapped onto the theme of *Leadership and safety ownership* and the dimension of *Management commitment* (Individuals are empowered by their management to take actions in the interests of flight safety) from Study 2 (Chapter 5).

Table 33.

Items considered to reflect perceptions of 'Management commitment to safety'.

Component sub-theme	Items	Mapping Study 1 themes
Management commitment	The Squadron Management encourages safe working practices Line management looks out for us here The Squadron Management is good at finding the right balance between addressing safety concerns and the requirement to achieve a task If a genuine error is made (resulting in an accident or near miss), management will always be supportive Good safety behaviour is positively recognised by the line management here The squadron management here do a good job balancing operational requirements against safety There is support from Management in safety critical situations	*Leadership and safety ownership*

The second sub-grouping of items were interpreted as being related to perceptions of management functions which supported organisational learning. While management plays a key role in the top-down enforcement of policies /procedures and informing priorities of work, it must also effectively garner and foster feedback from employees. Items shown in Table 34 included aspects of management listening to, and communicating with, employees, allowing and encouraging feedback and acting on safety concerns that have been raised. The items in Table 34 best mapped onto the theme of *communication* from both Studies 1 and 2. The content of the items contained on Component 1 led to this component being labelled *Management commitment to safety & organisational learning*.

Table 34.

Items considered to reflect perceptions of 'Organisational learning'.

Component sub-theme	Items	Mapping Study 1 themes
Organisational learning	Managers are quick to act on safety concerns when we report them Managers are willing to listen to staff when it comes to the best way to do something My supervisor / manager encourages me and my team to learn from safety events There is poor communication about safety issues that may affect me People here are kept informed about the outcomes of meetings which address safety issues My supervisor/manager encourages questions from workers about safety matters	*Communication*

One item did not appear to 'fit' into either sub-theme (Personal safety has a high priority here), and so it was noted that this item required consideration as to whether to retain or remove this item at later stages of the analysis/scale development.

Component 1 - Fit with Published Findings

Component 1 was well supported by published findings, as a general theme of management was seen to be common to all aviation safety climate research (O'Conner et al., 2011b; Weigmann et al., 2004) and other sectors (Dedobbeleer & Beland, 1998; Ek, 2006; Flin et al., 2000; Guldenmund, 2000; Seo et al., 2004). The naming of themes with similar foci varies between studies; including management style and communication (Harvey et al., 2002), management attitudes toward safety practices (Alhemood et al., 2004), line management commitment (Fung et al., 2005), perceptions of management (Sexton et al., 2006), management safety practices (Lu & Tsai, 2008), management safety priority and commitment to safety (Kines et al., 2011), management concern (Frazier et al., 2013), supervisory care (Huang et al., 2013) and safety commitment/communication (Ghahramani & Khalkhali, 2015). A management component within safety climate questionnaires was seen to date back to seminal safety climate research in the 1980's where Dov Zohar (1980) identified management commitment as a prerequisite to successful safety initiatives.

Beyond being the most commonly identified component, management commitment to safety has most often been the factor identified as explaining the largest percentage of the explained variance in safety climate measurement tools (Guldenmund, 2007). This is corroborated in the current study where it accounted for 14.5% of the explained variance.

This is perhaps to be expected where order is primarily determined by management as employees will interpret much of the 'state of safety' within in the organisation through observation of management safety behaviours (Guldenmund, 2010a). Furthermore, managers have far reaching effects as they control the human and material resources made available for certain activities and therefore are key to balancing (or not, as the case may be) the often-competing demands of safety and output. Employees of managers committed to safety have been shown to be more likely to expend efforts toward safety themselves (Guo, Yiu & Gonzalez, 2016).

Middle level managers are thought to play an intermediary role between senior and frontline staff, communicating safety priority from the former to the latter (DeJoy, 1994; Mearns, Rundmo, Gordon & Fleming, 2004; Simard & Marchand, 1994). At the same time, managers act as a conduit for information from frontline personnel to senior managers. This communication loop was the foundation for Reason's model (1997) of a 'learning' culture described in Chapter 2. While Reason's model has limited empirical evidence, Christian et al. (2009) showed positive relationships between safety climate and employee safety knowledge while management commitment to safety has been shown to have a predictive relationship with safety behaviours (Cheyne, Cox, Oliver & Tomas, 1998).

Semantic separation of levels of management on questionnaire items was achieved through using either 'My supervisor/manager' and 'Squadron management' (Guldenmund, 2010b; Kines et al., 2011). Despite this separation, however, Component 1 contained items relating to both levels of management. This might suggest that there was no clear discrimination between these management levels for respondents, although it should be noted that most personnel surveyed would have had little opportunity to observe senior management behaviour. Alternatively, it may have been that management practices were perceived as shared across all management levels (as was proposed by Kines et al., 2011).

Component 2: Normative Behaviour

Component 2 (Table 35) accounted for 13% of the explained variance and contained twelve statements which largely related to negative safety behaviours, such as taking shortcuts, supervisors not checking work before signing off on it and ignoring others' unsafe acts. Component 2 was therefore interpreted as reflecting the social (un)acceptability of negative safety behaviours amongst colleagues and supervisors. The nature of these behaviours reflects 'norms'; the accepted way of doing things that typically tends not to be in line with the formal policy and procedures. For this reason, Component 2 was named *Normative behaviour*.

Table 35.

Items loading onto Component 2.

Number	Item	Loading
Q50	People here take shortcuts when they think there is little or no risk involved	.710
Q8	Taking a short cut to get work done quickly is seen as acceptable, as long as nothing happens	.659
Q46	Managers turn a blind eye to rule bending	.651
Q74	Operational demands mean sometimes people have to take shortcuts	.642
Q60	Supervisors here sometimes encourage others to bend the rules or amend the procedure to achieve a task	.641
Q42	Supervisors sometimes sign off without checking	.573
Q48	People regularly get distracted when doing safety critical jobs	.526
Q43	People here are not comfortable reporting their own mistakes	.513
	Cross loading items	
Q62	*If people see others breaking a rule they tend to turn a blind eye*	*.615*
Q59	*People make mistakes because they are trying to do too many jobs at once*	*.434*
Q56	*Some safety procedures are only there to protect management's back*	*.453*
Q76	*If people followed all the safety rules they would not get the job done in time*	*.484*

One item (Q43, People here are not comfortable reporting their own mistakes), did not appear to fit well with the content of the other items on Component 2, and would have more face validity with the items in Component 4 (Reporting); this was noted for future development of the tool. There were several items which loaded highly (R>0.40) onto more than one Component (these are shown in *italics* in Table 35). Of these, one item referred to rule bending (Q62), two related to procedures/rules (Q56 and Q76) and one referred to making mistakes when trying to complete more than one job at a time (Q59).

When the *normative behaviour* component was compared to findings from Study 1, the items appeared to be related to a number of different themes from the qualitative phase (see Table 36). These themes included *leadership & safety ownership, individual & collective responsibility, policy & procedures,* and *pressure.* When compared to findings from Study 2, the items within *normative behaviour* appeared to map across most consistently to the dimensions of *priority of safety* (People do not take flight safety risks, even when work demands are high) and *Individual actions* (Everyone accepts that flight safety is their responsibility), the former of which was a particularly salient dimension to military aviation personnel (see Chapter 5). Possible reasons for this are articulated further in the Discussion (Section 6.4).

Table 36.

Component 2 themes, items and Study 1 theme mapping.

Component theme	Items	Mapping study 1 themes
Normative behaviour	People here take shortcuts when they think there is little or no risk involved	*Policy & procedures*
	Taking a short cut to get work done quickly is seen as acceptable, as long as nothing happens	
	Managers turn a blind eye to rule bending	*Leadership & safety ownership*
	Supervisors sometimes sign off without checking	
	Supervisors here sometimes encourage others to bend the rules or amend the procedure to achieve a task	
	If people see others breaking a rule they tend to turn a blind eye	
	Some safety rules are only there to protect management's back	*Policy & procedures*
	People here are not comfortable reporting their own mistakes	*Individual & collective responsibility*
	Operational demands mean sometimes people have to take shortcuts	
	People regularly get distracted when doing safety critical jobs	
	People make mistakes because they are trying to do too many jobs at once	
	If people followed all the safety rules they would not get the job done in time	*Pressure*

<u>Component 2 - Fit with Published Findings</u>

Normative behaviour predominately reflected those behaviours which would not conform to the prescribed procedures/tasks and thus are presumably likely to incur some level of risk. In Study 1, personnel cited a high adherence to rules and procedures as normal, considering them both necessary and the safest way to do a task. However, examples were given for why personnel might not be able to comply with these, and two items contained on Component 2 directly illustrate some of these reasons (Q74, ‘Operational demands mean sometimes people have to take shortcuts’ and Q8, ‘Taking a short cut to get work done quickly is seen as acceptable, as long as nothing happens’). Dekker (2003) identified non-adherence to procedures as a key contributor to aviation accidents, suggesting that a gap between policy and practice was common, and could give rise to 'norms' of behaviour. The tension between following rules and procedures in the face of work pressure is an area commonly identified as a 'trade-off' across various industries (Weyman & Clarke, 2003) and maintaining the balance between them has been suggested as key to a positive safety culture (Advisory Committee on the Safety of Nuclear Installations (ACSNI), 1993). Increased cost reduction and organisational restructuring has been suggested as having a significant impact on safety behaviour when time or resources are stretched (Flin et al., 2000).

Component 2 is analogous to published findings on safety climate measures related to rules/procedures or risk (Flin et al., 2000, Guldenmund, 2000), variously labelled as risk taking (Lu & Tsai, 2008; Frazier et al., 2013; Fung et al., 2005), risk taking behaviours and risk perceptions (Harvey et al., 2002), and positive safety practices (Ghahramani & Khalkhali, 2015, represented by items such as 'Stop working due to safety concerns' and 'Availability of enough people to do the job safely'). Lu and Tsai (2008) reported two factors; one labelled 'Co-worker safety practices' (including items such as 'My co-workers encourage others to be safe' and 'My co-workers follow safety rules') and the other 'safety attitudes' (includes items such as 'I ignore safety regulations to get the job done' and 'I will ignore safe working procedures for convenience'). The items in Component 2 are interpreted here as being more related to risk taking behaviours which have been shown to be influenced by knowledge, training, and an individual's sense of personal responsibility for safety (Flin & Yule, 2004).

Component 3 - Training and Experience

Component 3 contained 6 items (see
Table 37) and accounted for 8.8% of the variance in the PCA. Items all appeared to relate to perceptions of personnel's levels of training or experience. Three of the items made reference to colleagues having sufficient training or experience to conduct their jobs safely, while two items made reference to supervisory availability and experience. One item cross loaded on to both Component 3 and Component 4 (*reporting*), and referred to personnel working safely even when supervisors were not there to observe their work. The general theme of this Component was therefore interpreted as being related to the level of competence of personnel within the organisation, a combination of both *training* and *experience*. Within the FAA this is better known as Suitably Qualified and Experienced

Personnel (SQEP) which illustrates the fact that in this organisation both training (qualifications) and experience is required to be considered competent.

Table 37.

Items loading onto Component 3.

Number	Item	Loading
Q32	In general, supervisors are sufficiently experienced to meet the required level of supervision	.808
Q41	People are sufficiently experienced for the jobs they are required to do	.769
Q33	Everyone here is sufficiently trained to undertake their tasks safely	.740
Q52	There are always supervisors available to give advice	
Q19	People here are not always confident that they have the experience to do the job	.532
	Cross loading items	
Q37	*People here always work safely, even when they are not being supervised*	*.439*

Items on Component 3 mapped directly onto the theme of *Training/experience* (within Study 1) which was identified as a key influencer of safety culture in Chapter 4. These items also appeared to map clearly onto the *Safety training* (Flight safety training is an integral part of all routine training) and *competency/experience* (People here are sufficiently competent and experienced to do the jobs they are required to do safely) dimensions utilised in Study 2 (Chapter 5).

Component 3 - Fit with Published Findings

Both training and experience have been identified as key to influencing safety culture (Flin et al., 2000; O'Conner et al., 2011b). Variants of this theme have been labelled as safety training (Lu & Tsai, 2008), general training (Frazier et al., 2013; Huang et al., 2013), safety involvement and training (Ghahramani & Khalkhali, 2015), training/standards (Flin et al., 2000) and competence (Keren et al., 2009). Several authors have proposed that training underpins safety culture (Diaz-Cabrera et al., 2007; Lawrie et al., 2006) because it can determine employee work performance (Graham, Ramirez, Finlay, Hoy & Richards, 1996). Higher levels of training have also been shown to predict actual safety behaviour (Cooper & Phillips, 2004; Reber & Wallin, 1984), correlate positively with safety climate scores (Lu & Shang, 2005) and correlate negatively with accident rate (Smith, Cohen, Cohen & Cleveland, 1978).

Component 4: Reporting

Component 4 accounted for 6.7 % of the variance and contained five items (Table 38). Three items related directly to aspects of reporting, whether people in the organisation report safety related occurrences and unsafe acts as well as errors made by colleagues, thus Component 4 was labelled as *reporting*. Two items cross loaded onto either Component 3 (*training & experience*, Q37, People here always work safely, even when they are not being supervised) or Component 2 (*normative behaviour,* Q62, If people see others breaking a rule they tend to turn a blind eye). When considered against the other components identified thus far, there was some conceptual overlap between Component 4 and that of *management commitment to safety/organisational learning* and *normative behaviours*. Organisational learning depends on feedback from front-line staff, which often occurs in the form of reporting of errors or safety occurrences. Similarly, if personnel consider reporting to be worthwhile, it may become the 'norm' to report such occurrences. It is, however, interesting, that this component was identified separately in the PCA.

Table 38.

Items loading onto Component 4.

Number	Item	Loading
Q6	If people here saw an unsafe act they would report it	.707
Q18	Most people in my workplace report safety related occurrences	.695
Q34	If I thought no one would know, I would not report a colleague's error	.551
	Cross loading items	
Q37	*People here always work safely, even when they are not being supervised*	*.420*
Q62	*If people see others breaking a rule they tend to turn a blind eye*	*.425*

Items contained in Component 4 were directly related to the theme of *'Communication'* described in Chapter 4 (Study 1) which, despite the organisation's reporting system being described as time-consuming to use and providing little feedback to the reporter, was seen to be key in facilitating learning. Component 4 was also observed to link most closely to the *Communication* dimension in Study 2.

Component 4 - Fit with Published Findings

Within published literature, reporting of safety concerns or errors has been identified as important, and has either been categorised as part of the safety system (Flin et al., 2000), or as a standalone safety climate item (Frazier et al., 2013). Reporting of incidents is said to be an individual responsibility in organisations with a positive safety culture, and is a key aspect of Reason's (1997) safety culture model as an enabler of the learning account. The concept of a 'reporting culture' as described by Reason (1997) forms part of an organisational risk management strategy to provide early warning of potential risks, however this can be hindered if reporting is associated with blame and culpability (Nordlof et al., 2015; Weyman et al., 2006). To counter this, and encourage reporting, Reason (1997) advocated the adoption of a 'Just culture', a message which is adopted in the Nimrod Review (Ministry of Defence, 2009) and promulgated through the FAA (see Study 1 findings, Chapter 4). A just culture is suggested to be one in which people are encouraged and supported to volunteer safety related information in a context where acceptable and unacceptable behaviour is made clear (Reason, 1997).

Component 5: Human Resources

The fifth component identified in the PCA accounted for 6.3% of the explained variance and contained four items (see Table 39). Three of the items referred directly to the availability of personnel resource; whether there were enough people to complete jobs safely, (Q68), whether they would be re-tasked if required for safety reasons (Q2) and whether the manning levels could support operational demands (Q57). One of the items (Q59, People make mistakes because they are trying to do too many jobs at once) was seen to cross-load onto Component 2 (*normative behaviour*) which is a potential consequence of a lack of adequate human resources (or the work pressure caused by this). All four items were interpreted as referring to aspects of *human resources* and so this was chosen as the label for Component 5.

Table 39.

Items loading onto Component 5.

Number	Item	Loading
Q68	There are enough people to do the job safely	.715
Q2	More people are made available to do a job if needed for safety reasons	.670
Q57	Manning is appropriate to meet operational demands	.668
	Cross loading item	
Q59	*People make mistakes because they are trying to do too many jobs at once*	*.432*

Study 1 identified a number of sources of pressure placed on military aviation personnel, of which a lack of human resources was one, and therefore it was the theme of *pressure* to which the items on Component 5 were aligned. This also directly mapped onto the *human resources* dimension (There are enough people to do the job safely) from Study 2 and was the most salient (most negatively ranked, being judged least 'like' the workplace) influence on safety for military aviation personnel (see Chapter 5). A lack of personnel resource was acknowledged as an organisational challenge within all of the focus group discussions (Chapter 4), with personnel describing *"being asked to do more with less"*, thus placing increased pressure on the remaining personnel. In the current global economy, this pressure is perhaps unsurprising, but is important; increased pressure on personnel could lead to shortcuts being taken or personnel being overloaded and distracted, either of which would potentially negatively affect overall safety.

Component 5 - Fit with Published Findings

Issues of personnel resource tend to be identified alongside other workplace pressures on most safety climate measures, rather than separately (Guldenmund, 2000). A notable exception to this was Olsen (2008) whose component 'Staffing' appeared similar to the current findings. Olsen (2008)'s study population was that of healthcare professionals; a sector which has been suggested to be particularly susceptible to inadequate staffing levels. Guldenmund (2007) identified manpower planning as part of the management system, from policy making, through to work schedules and the amount of people available to do a job, and highlighted the negative effect that inadequate resource may have on safety behaviours. This is therefore, perhaps, one of the most integral aspects of safety and risk management as it has a number of knock-on effects on competence and training, work scheduling, work output and pressure.

Component 6: Process and Bureaucracy

The final component in the PCA accounted for 5.9% of the variance and contained five items. At the heart of this final component appeared to be issues surrounding the 'red tape' involved with reporting safety concerns (Q63 and Q70), and whether procedures are seen to be simply process measures to allocate culpability (Q71 and Q56). Table 40 shows these items and their factor loading, with this component being labelled as *process/bureaucracy.* These items show an interesting contrast to those in the *reporting* component; the items on Component 6 refer not to whether reporting was seen important, but rather whether it was *easy* to do.

Item 56 (Some procedures are only there to protect management's back) was observed to cross load with equal weighting onto Component 2 (*normative behaviour*, R=0.453), however when considering the items on each component, it was determined that there was more face validity for retaining item 56 on Component 6. The final item within this component referred to the incompatibility with safety procedures and the time allocated to complete tasks (Q76), which also cross-loaded onto Component 2 (R=0.484).

Table 40.

Items loading onto Component 6.

Number	Item	Loading
Q63	There is too much paperwork involved with reporting safety concerns	.777
Q70	It is too bureaucratic to report all safety concerns	.712
Q71	Safety rules / procedures are only there to protect against legal action	.611
	Cross loading items	
Q76	*If people followed all the safety rules they would not get the job done in time*	.462
Q56	*Some procedures are only there to protect management's back*	*.473*

When the constituent items on Component 6 were considered against the themes detailed in Study 1, it was determined that they mapped onto two themes (see Table 41), *communication* and *policy and procedures,* specifically the sub-theme of *cultural legitimacy*. Given the high levels of legitimacy afforded to procedures by personnel in Study 1, it would be expected that ratings on the items in Table 41 would be positive, indicating positive perceptions of procedures. When compared to findings from Study 2, there were no comparable dimensions (Chapter 5).

Table 41.

Component 6 themes, items and Study 1 theme mapping.

Component theme	Items	Mapping study 1 themes
Process & bureaucracy	There is too much paperwork involved with reporting safety concerns	*Communication*
	It is too bureaucratic to report all safety concerns	
	Safety rules / procedures are only there to protect against legal action	*Policy & procedures*
	Some procedures are only there to protect management's back	

Items Q63 and Q70 related to the theme of *communication*, specifically *barriers to reporting*. It is of interest that these items did not load onto the same factor as items within Component 2 (Q34, If people here saw an unsafe act they would report it, Q18, Most people in my workplace report safety related occurrences and Q43, People here are not comfortable reporting their own mistakes). At first glance these items would appear to be related; they are all nominally related to the topic of reporting. However, the difference between these is that one set related to the perceived importance of reporting (those loading on Component 4), and the other set related to the perceived ease of reporting (those loading on Component 6). These two, it is argued, are not necessarily the same - personnel may acknowledge the importance of reporting, however the actual implementation of the reporting system may either support or hinder actual reporting. Ideally, reporting systems should be intuitive and easy to access/complete in order that the act of reporting near misses or accidents does not become an unnecessary burden on already busy employees.

Component 6 - Fit with Published Findings

Process/bureaucracy related to two aspects of the safety system (procedures and reporting) and had not been specifically identified as a separate component within any safety climate studies reviewed in this thesis. The conceptual foundation of this component can, however, be linked to the concept of bureaucratization of safety (Dekker, 2014) which refers to the escalating number of administrative layers which govern how safety is managed and where individuals are increasingly held accountable. Regulation of safety in the UK military aviation sphere was centralised after the publication of the Nimrod report (Ministry of Defence, 2009), and it has been acknowledged by the industry regulators (Military Aviation Authority, 2014b) that this process has resulted in considerable, widespread changes to policy and process. This reflects similar increased regulation within other UK sectors (Dekker, 2014). It is reasonable to conjecture that this may have been interpreted by FAA employees as unnecessarily increased safety process. Power (2004) discussed similar themes in relation to risk management, where he suggested that the rise in accountability and culpability associated with risk management resulted in significant secondary risk management and burgeoning internal control mechanisms used to detail accountability at each decision-making stage.

Summary

In summary, an exploratory PCA revealed six components which were considered to characterise safety climate within the FAA. These findings were interpretable with reference to published findings, and the component *process & bureaucracy* was considered to be a novel component.

6.3.3 Partial Confirmatory Factor Analysis

Using results from the PCA analysis (Bartlett's χ^2=11974.625, *df*=1770; Goodness of fit χ^2=1446.946, *df*=1165, contained in Table 8 of Appendix D), the PCFA returned encouraging results (RMSEA=0.023, NFI=0.88, TLI=0.99 and CFI=0.97). These values were all suggestive of a good model fit (Bentler & Bonett, 1980, Bentler, 1990; Gignac, 2009; Tucker & Lewis, 1973) and so it was determined that the safety climate components determined by the PCA in this study would benefit from a confirmatory factor analysis using an independent sample of participants. This further analysis is detailed in Chapter 7 (Study 4).

6.4 Discussion

The PCA revealed six nameable constructs which were characterised as (i) *management commitment to safety & organisational learning*, (ii) *normative behaviour*, (iii) *training/experience,* (iv) *reporting*, (v) *human resources* and (vi) *process/bureaucracy*. Table 42 provides an overall summary of how these six components aligned with findings from Studies 1 (Chapter 4) and 2 (Chapter 5).

Table 42.

Overall mapping of Study 3 components, Study 2 dimensions and Study 1 themes.

Study 3 components	Study 2 dimensions	Study 1 themes
Management commitment to safety & organisational learning	Management commitment/ management actions	Leadership & safety ownership
	System safety, procedures & policy	Communication
Normative behaviour	Individual actions/ individual responsibility	Individual & collective responsibility
	Priority of safety	Leadership & safety ownership
		Policy & procedures
		Pressure
Training & experience	Safety training	Training & experience
	Competency/experience	
Reporting	Communication	Communication
Human resources	Human resources	Pressure
Process/ bureaucracy		Policy & procedures
	Working environment	

Table 42 shows that when the findings from the current study are mapped across to Study 1 and 2 findings, there is notable similarity between some of the components (e.g. *training/experience, reporting* and *human resources*) while other components map to multiple dimensions/themes (e.g. *normative behaviour*, *process/bureaucracy* and *management commitment to safety & organisational learning*). This may highlight the complex nature and interaction of safety climate variables in this context, and similarities/differences between the findings from the studies are discussed in more detail in the following section.

6.4.1 Management commitment to safety & organisational learning

Component 1 (*management commitment to safety & organisational learning)* reflected the importance of perceptions of management and their commitment to safety and mapped onto similar concepts in both Studies 1 (*Leadership & safety ownership*) and 2 (*Management commitment*). Component 1 contained 14 items which all referred to different aspects of management responsibility, so it was perhaps unsurprising to note that this component also mapped across to other themes (see Table 42) from Studies 1 and 2 (e.g. *safety system* and *communication* respectively). This arguably reflects the complexity and breadth of the formal influences that management has over safety activities.

Formally, management influence safety through resource allocation (Guo et al., 2016), implementation of policy and procedures and compliance monitoring (Hale & Borys, 2013), communication of safety priorities (Mearns, Rundmo, Gordon & Fleming, 2004; Simard & Marchand, 1994), investigation of accidents and subsequent application of mitigation measures (DeJoy, 1994) and supporting safety performance (Buttrey et al., 2010). Empowered leadership has been shown to lead to improved employee safety participation, but this relationship was mediated by collaborative team learning (Martínez-Córcoles et al., 2012). Similar factors have been identified and labelled as 'safety prioritisation' (Tharaldsen, Olsen & Rundmo, 2008), 'unsafe work behaviour' (Farrington-Darby et al., 2005; Flin, 2007; Seo, 2005), and ' peer support' (Frazier et al., 2013). This collaborative learning can arise from observation of colleagues and then use of these observations to determine the acceptability and meaning of safety-related behaviour (Dooley, 1996; Meyer & Rowan, 1977). This is supported by previous safety climate research in which group-level practices are shown to affect safety accident risk (Zohar, 2000).

6.4.2 Normative Behaviour

The second component identified through the PCA was named *normative behaviour*, and accounted for similar levels of explained variance (13%) as Component 1 (14%). While Component 1 was interpreted as reflecting the formal influences on safety, Component 2 was thought to reflect informal influences within the organisation. Items within *normative behaviour* mapped across to a number of themes from Study 1 (*individual & collective* *responsibility*, *leadership & safety ownership*, *policy & procedures* and *pressure*) and two dimensions from Study 2 (*individual actions*, *priority of safety*). Consideration of items within Component 2 showed a variety of influences that may arise from colleagues/peers which may encourage/discourage employees from working safely, as well as informal behaviour by managers.

Military groups have often been characterised by their strong team-work and cohesive work units, group loyalty and respect for colleagues (Tinoco & Arnaud, 2013). This cohesiveness has been linked to personal ownership of safety (Clarke 2010; Geller et al., 2001) but also with peer pressure and unwillingness to speak up against group norms (Falconer, 2006b). It may be this cohesiveness which underpins the prominence with which the component of *normative behaviour* appears to have; watching and learning safety behaviour from what others do around them may be particularly important in a group of people who 'look out' for each other.

6.4.3 Training and Experience

Component 3, *training and experience* was mapped across directly to similar dimensions/themes observed within Studies 1 and 2 (see Table 42). Indeed, safety training has widely been identified as a reflection of competence (Flin et al., 2000; O'Conner et al., 2011b), a predictor of safety behaviour (Cooper & Phillips, 2004; Lawton, 1998; Reber & Wallin, 1984) and being significantly related to errors (Bazargan & Guzhva's (2011). However, in a similar factor analytic study of safety items, authors such as Glendon and Litherland (2001) reported that items related to training were not retained in their construction safety climate scale, and thus conjecture that not all safety climate factors are stable across industries. In contrast with components contained within many safety climate tools, which focus exclusively on training (Flin et al., 2000; Guldenmund, 2000), the current study would suggest that there is also an apparent importance of *experience*, appearing across both the qualitative themes and quantitative components. In Chapter 4, aircrew specifically discussed the differences between training and experience in that training was seen as generally sufficient, but that a lack of resources may lead to a lack of experience for them in certain situations.

6.4.4 Reporting and Process/Bureaucracy

It was of interest that items related to reporting were identified in the current study to differentially load onto two components, *reporting* (Component 4) and *process/ bureaucracy* (Component 6). Studies 1 and 2 contained themes/dimensions related to *communication* which were seen to overlap with components 4 and 6 in the current study. The proposed reasons for this are discussed further here. In Study 3, items retained on the component *reporting* referred to the importance of reporting unsafe acts, errors and safety occurrences. Two items within *process/bureaucracy* also described reporting, but these items focused on the organisational process by which people report, and whether it was easy to do so. The differentiation between these two subtle aspects of reporting triangulates on some findings reported in Study 1, in which personnel appeared to universally accept the importance of reporting safety occurrences (to enhance the organisational learning), but also detailed a number of barriers which would stop them from reporting these safety occurrences. Similar barriers have been described in civilian helicopter emergency services (Chesters, Grieve & Hodgetts, 2016) and aviation ground handlers (Ek & Akselsson, 2007).

Accident/near miss reporting has been identified as an integral part of the 'safety system' (Block, Sabin & Patankar, 2007) and is a key feature in Reason's safety culture model (1997). In aviation particularly, reporting has high salience (Diaz-Cabrera et al., 2007; Jausen, Silva & Sabatini, 2017) as it promotes organisational learning (Edmonson, 1996). However, despite an industry-wide drive toward confidential and non-punitive reporting systems, several authors have noted the high degree of under-reporting of safety occurrences in aviation (Gilbey et al., 2015), potentially due to organisational barriers such as inadequate resource allocation, inadequate feedback/usability (Jausen, Silva & Sabatini, 2017; Lawton & Parker, 2002), inadequate information technology, workplace barriers such as peer influence and bureaucracy (Atak & Kingma, 2011) and individual barriers such as fear of consequences, lack of competence and lack of knowledge (Hale & Borys, 2013).

6.4.5 Human Resources

Study 1 (Chapter 4) highlighted a number of different sources of *pressure* which were described as influencing safety behaviour, including secondary roles, lack of resources (equipment and personnel) and interdependence of aircrew and engineering functions. While several items related to these pressures loaded onto a number of the components identified in the PCA, items related to the availability of personnel to complete and supervise work safely loaded onto a separate component (Component 5), which is labelled here as *human resources*. One of the items shown to cross-load reflected the possible effects of inadequate personnel resource, namely that people make mistakes because they are trying to do too many things at once.

Although this component is not typically identified as a separate construct within the wider safety culture/climate literature (other than the cited study by Olsen, 2008), similar items are often contained in themes labelled as pressure (Flin et al., 2000; Guldenmund, 2000). In the revised US Navy safety climate tool suggested by O'Conner et al. (2011a), there is a component labelled 'availability of resources', which refers to general resources, without detailing personnel resource as a separate item. Within the current organisation, the finding that these items loaded onto a separate component might suggest that it is a key one of interest. This is corroborated findings from Study 2, where a lack of *human resources* was identified as a stand out safety concern, while in Chapter 4, focus group participants discussed the tension between being expected to maintain a certain level of output, despite having fewer people. Along with many modern industries, the UK Armed Forces have been placed under pressure to reduce their operating costs, and the Strategic Defence Security Review (SDSR) of 2010 detailed a required reduction in personnel resource as a key means to achieve this.

6.5 Conclusions

This study aimed to identify a finite set of components considered to characterise headline influences on workplace safety climate in the FAA. This aim was achieved through identification of six components: *management commitment to safety & organisational learning*, *normative behaviour*, *training/experience, reporting*, *human resources* and *process/bureaucracy.*

A set of seventy-eight scalable items in a self-report questionnaire format was completed by a sample of FAA personnel (meeting objective one). In order to explore the factor structure of variables that characterise safety climate in a military naval aviation population, a principle components analysis was undertaken. This revealed a pattern of six components that accounted for 55.1% of the total explained variance (meeting objective two).

In order to meet objective three, the identified components were compared and contrasted with published findings within Sections 6.3 and 6.4 of this Chapter. Findings were supported by, and interpretable with reference to, established research findings.

In relation to consideration of the scope and appropriateness of using the revealed component structure as the basis for developing a set of psychometric safety climate scales (objective four), results from a partial confirmatory factor analysis suggested that further development and validation of the safety climate scales was appropriate. This was undertaken in Study 4 (Chapter 7).

Chapter 7: Towards the Development of a Safety Climate Tool for use in Military Naval Aviation (Study 4)

7.1 Introduction

7.1.1 Purpose of the Project and Rationale

The following chapter builds on findings from Study 3 (Chapter 6) where an exploratory analysis of questionnaire items resulted in the development of a provisional multi-dimensional model of safety climate amongst naval aviation personnel. The aim was to further refine this through validation of the factor structure identified in Chapter 6 and assessment of the psychometric properties of the constructs to produce a set of safety climate scales. This culminated in an exploration of the discriminant properties of the scales, through exploring the profiles of an array of military naval aviation personnel structural demographics e.g. by function (role) and rank.

The chapter provides an account of the confirmatory analysis performed, and an exploration of demographic differences using respondent ratings on the safety climate proto-scales. This was undertaken to advance knowledge in this area of research through identifying the potential group safety climate profiles. Findings were interpreted with reference to insights derived from the empirical qualitative evidence gathered (from Chapter 4), the exploratory ranking study (Chapter 5) and published findings (Chapter 2). Development of a climate tool of this type was held to provide the FAA with the ability to benchmark employee perspectives, characterise differences by demographic group, and use this information to identify priorities and direct resource allocation for intervention and improvement of safety.

7.1.2 Aims

1. To determine the validity of the six-factor solution identified in Study 3 and explore the scope for using this to produce a safety climate assessment tool for use in a military naval aviation context.
2. To develop these derived constructs into a set of sub-scales with the capacity to profile and benchmark safety climate, provide a relative indicator of change over time and detect demographic differences.

7.1.3 Objectives

1. Determine the validity of the component structure identified in the PCA by undertaking a confirmatory factor analysis (CFA) on a further sample of the organisation's employees.

2. Reliant on an acceptable model, refine the output of the CFA to produce a set of scales that possess high face validity and exhibit good reliability properties.

3. Explore the capacity of the developed construct scales to profile and discriminate between different groups of employees.

7.1.4 Background

Safety climate scales and measurement tools are held to be useful to (i) provide an evidence-based approach to gathering feedback on employee perceptions of safety-related corporate priorities, emphasis and custom and practice, behavioural norms in relation to safety systems and the practical utility and functional status of those systems; (ii) act as a diagnostic tool in distinguishing between organisational units in detecting safety climate differences, and (iii) for evaluating the effect of interventions (Kines et al., 2011). The capacity to recognise and understand differences in perceptions of safety climate amongst different groups embodies the potential for safety managers to adopt a targeted approach to intervention, thereby concentrating scarce resources.

7.2 Method

The PCFA completed in Chapter 6 indicated that further data collection with a second sample of personnel was appropriate as findings were indicative of a good model fit (RMSEA=0.023, NFI=0.88, TLI=0.99 and CFI=0.97).

7.2.1 Ethical approval

Permission to undertake the study was granted by both MODREC (reference 648/MODREC/15) and the University of Bath (15-194).

7.2.2 Sample

Data was collected from a second sample of participants using the 78-item questionnaire detailed in Chapter 6. FAA operational considerations meant that the same data collection method detailed in Study 3 could not be used. Instead, a sample of volunteers was drawn from monthly safety training courses which were run by the organisation's Flight Safety team, and data collection was facilitated by this team rather than by the researcher. Military naval aviation personnel from across the UK attend this training as part of their career development.

There is no universally agreed requirement for sample size for CFA, however Hoyle (2000) and Tabachnick and Fidell (2014) both recommended a sample of at least 200 participants. Given the initial sample of 441 personnel for the PCA, a sample of approximately 300 personnel was deemed to be acceptable for undertaking the CFA. In total 330 personnel completed questionnaires, of which nine data sets were removed as they had more than 10% of their data points missing, leaving a final sample of 321 data sets. Of these, demographic data for 211 respondents was not collected due to administrative issues and non-response to these questions by respondents. It is possible that the administration of the questionnaires by course administrators may have led respondents to doubt the confidentiality of their data. The available demographic information for respondents from the second sample used for the CFA is shown in Table 43. When compared to the respondent sample for the PCA (Table 27, Chapter 6), the distribution of participants across the groups is similar, with a larger proportion of engineers than aircrew, and few junior aircrew respondents.

Table 43.

Demographics of the sample for respondents who provided demographic data (N=118), (entire sample N= 330, demographic data were not available for 212 respondents).

	N=118
Aircrew	Junior ratings N= 2
N=32	Senior ratings N= 7
	Officers N= 23
Engineers	Junior ratings N = 69
N=86	Senior ratings N = 16
	Officers N = 1

7.2.3 Procedure

Steps were taken to keep the procedure for data collection as similar as possible to that used in Study 3 (Chapter 6). Data collection was undertaken between March and August 2017 and typically took place on the first day of the course. Questionnaires were administered and collected by a member of the course delivery team and sent to the researcher. Participants were given time during the course to participate and the questionnaire took approximately 15-20 minutes to complete.

7.2.4 Data Analysis

CFA is used to test whether a pre-determined factor structure fits the data, and is considered a more sophisticated technique than PCA (Mearns et al., 2013). Tabachnick and Fidell (2014) suggested that, when used in the latter stages of the research process, this method can be used to corroborate theory about the underlying relationship amongst variables. In CFA, a theoretical model is set up, and the data is then analysed to determine how well they 'fit' the theoretical model. In the current study, CFA was considered appropriate because the author wanted to test the theory of the underlying factors identified in Study 1 and to determine whether safety climate was a multi-dimensional construct amongst this population. Furthermore, the CFA is an important step in refining and revising questionnaires (Mearns et al., 2013).

AMOS 23 software was used to perform the CFA, using the six-factor model containing forty one items which was developed in Study 3 (Chapter 6). These components, and constituent items are contained in Appendix E (Table 1). Table 44 shows the internal reliability statistics (Cronbach alpha) for each component. Any missing values were replaced with the mean of the item ratings (as recommended by Hoyle, 2000).

Table 44.

Six components from PCA, showing internal reliability (Cronbach alpha α) of each component.

PCA Component (Chapter 6)	Number of items	Cronbach alpha (α)
1 - Management & organisational learning	14	0.908
2 - Normative behaviour	8	0.898
3 - Training & Experience	6	0.841
4- Reporting	4	0.804
5 - Human resources	4	0.710
6 - Process/bureaucracy	5	0.786

Goodness of Fit Indices

A range of measures of model fit (goodness of fit indices) were consulted to inform the acceptability of the model fit to the data. This process allowed for assessment of the relationship between the measures (i.e. the items/indicators) and the constructs they were designed to measure (Hoyle, 2000). Fit indices are grouped into two categories - absolute fit indices and incremental fit indices (Hooper, Coughlan & Mullen, 2008). Absolute fit indices determine how well an *a priori* model fits the sample data (Hooper et al., 2008), while incremental fit indices compare the proposed model to a baseline model (Bentler & Bonett, 1980). Absolute fit indices use the chi-square value in the model in its raw form while the incremental fit indices do not. Using the raw chi-square statistic is the traditional method, however it has been suggested that this holds several limitations (Hooper et al., 2008) including (i) that it assumes multivariate normality and deviations will incur rejection of the model even if it is correctly specified and (ii) its sensitivity to sample size. Therefore, a combination of both was utilised in a systematic manner (in line with Hooper et al., 2008 & Hoyle, 2000).

Absolute Fit Indices

The absolute fit indices utilised were the chi-square (χ^2), the Goodness of Fit Index (GFI), the Root Mean Square Residual (RMR), the Root Mean Square Error of Approximation (RMSEA) and the closeness of fit (PCLOSE) index.

A large value, significant result for the χ^2 index indicates good model fit (Furr, 2011). Large samples tend to return large values which are significant (Joreskog & Sorbom, 1993) and so this index was combined into a ratio with the degrees of freedom (DF), creating the CMIN/DF ratio (Byrne, 2010). A CMIN/DF ratio of lower than 5 is considered to indicate good model fit (Byrne, 2010).

The GFI is a measure of the relative amount of variance and covariance in the sample data and varies from 0 to 1, with higher values indicating better model fit (Byrne, 2010). Typically, a GFI of greater than 0.90 is considered to indicate acceptable model fit (Bentler, 1990; Byrne, 2010; Hoyle, 2000). The RMR represents the average residual value derived from fitting of the model, with smaller values indicating a good model fit; values of 0.05 or less are considered acceptable (Byrne, 2010). The RMSEA indexes the degree of discrepancy between observed and implied covariance matrices per degree of freedom (Hoyle, 2000) and was recently identified as one of the most informative indices (Byrne, 2010). The threshold of good model fit for the RMSEA has been debated, with values of less than 0.06 said to indicate good fit (Hu & Bentler, 1999), and values of lower than 0.05 as indicating very good fit (Browne & Cudeck, 1993; MacCullum & Austin, 2000). The final goodness of fit index, PCLOSE had a threshold of 0.05 to indicate a good model fit (Byrne, 2010; Joreskog & Sorbom, 1996).

Incremental Fit Indices

The most commonly used incremental fit index is the CFI. CFI values can range from 0 to 1, with higher values indicating better fit (Bentler, 1990). Some authors recommend a threshold of 0.90 to indicate good fit (Bentler & Bonett, 1980; Bentler, 1990, Mearns et al., 2013) whilst others argue that this value should exceed 0.95 (Hu & Bentler, 1999).

The absolute and incremental fit indices, along with the criteria for good model fit described above are summarised in Table 45.

Table 45.

Summary of goodness of fit indices for CFA with criteria for good model fit.

Index	Indicator of good model fit
χ^2	Low value, non-significant result
CMIN/DF	Less than 5
GFI	Greater than 0.90
RMR	Less than 0.05
CFI	Greater than 0.90
RMSEA	Less than 0.05 (with 95% Confidence interval)
PCLOSE	Greater than 0.05

7.3 Results

7.3.1 Confirmatory Factor Analysis

The CFA was run with forty-one items within six components, as identified by the PCA detailed in Chapter 6. Testing the hypothesised underlying factorial structure on all forty-one items showed poor fit (χ^2 =1387.938, DF =724, p<0.001; GFI =0.827, CFI =0.879, RMSEA= 0.053), although two indices were acceptable (CMIN/DF = 1.917; PCLOSE= 0.100). The hypothesised model containing standardized estimates can be found in Figure 1 of Appendix E, and the full list of indices in Table 46.

Table 46.

Goodness of fit indices for hypothesised model, 6 factors and 41 items, showing poor model fit (Model 1, Appendix E).

Index	Results
χ^2	1387.938, DF=724, p<0.0001
CMIN/DF	1.917
GFI	0.827
RMR	0.053
CFI	0.879
RMSEA (CI)	0.053 (0.049-0.058)
PCLOSE	0.100

These findings showed that the hypothesised six factor model derived from the PCA could not be confirmed through CFA on an independent sample. However, modification indices showed correlation errors for a number of items (likely due to similar item content), Therefore, a series of exploratory models were run, by re-specifying the model taking these factors into account. This process of re-specification is common in most applications of CFA and involves either freeing fixed parameters or fixing free parameters (Hoyle, 2000). This led to slight improvements in the model (Table 47) which comprised of six factors and thirty-nine items (Management 12 and Norm 4 were removed due to kurtotic data). Here, the CFI value approached a good model fit, as did RMSEA and RMR values.

Table 47.

Goodness of fit indices for re-specified model, 6 factors and 39 items, showing improved model fit indices (Model 2, Appendix E).

Index	Results
χ^2	1230.850, DF=685, p<0.0001
CMIN/DF	1.797
GFI	0.839
RMR	0.050
CFI	0.897
RMSEA	0.050 (0.045-0.054)
PCLOSE	0.543

It was noted that the *human resources* component displayed poor standardised estimates on two of the items (0.50 and 0.55) as did one item on the *process*/*bureaucracy* component (0.42) and one on the *normative behaviour* component (0.54), and these items were removed (in line with Hoyle's, 2000 recommendations for model re-specification). The removal of two *human resources* items left a scale with only two items, which is not suitable (Openheim, 2000) and so the decision was made to remove the entire *human resources* component from the re-specified model. This process of optimising parameter estimates is iterative, and so incremental attempts to increase these were continued, until parameter estimates offered no appreciable improvement in the estimation criterion (as recommended by Hoyle, 2000).

Table 48.

Goodness of fit indices for final re-specified model, 5 factors and 32 items, showing acceptable model fit.

Index	Results
χ^2	712.290 DF=448, p<0.0001
CMIN/DF	1.590
GFI	0.882
RMR	0.039
CFI	0.936
RMSEA	0.043 (0.037-0.049)
PCLOSE	0.100

The goodness of fit indices for the final, re-specified model are shown in Table 48, with the indices showing an acceptable model fit for this five-factor, thirty-two item safety climate model. The standardised residuals for the model are shown in Figure 5.

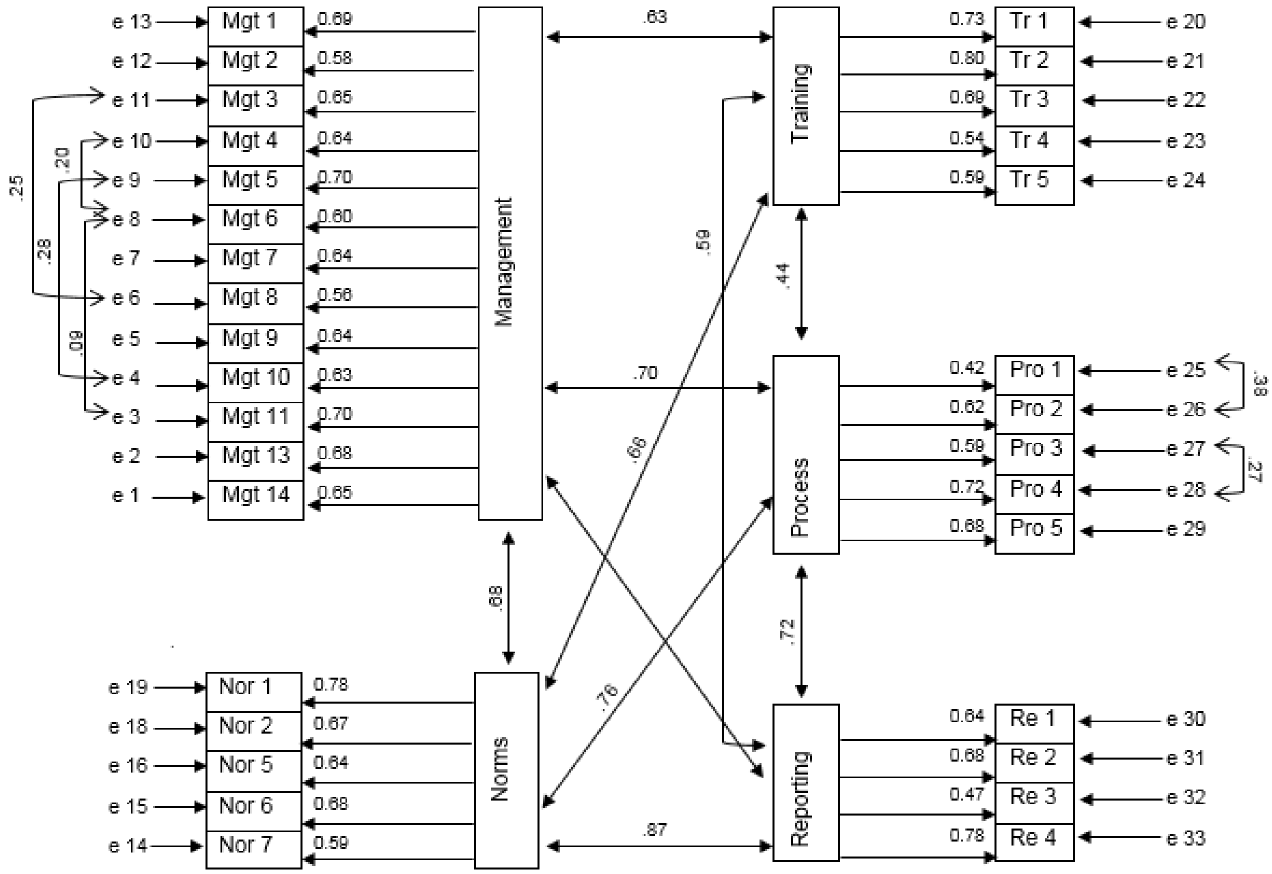

Figure 5. Standardised estimates (N=483) for the final, re-specified model (GFI=0.882, CFI=0.936, RMSEA=0.043).

7.3.2 Refinement of the Scales and Exploration of Demographic Differences

Once an acceptable re-specified model was successfully completed, the study then looked to develop each of the components, and their constituent items, into a set of proto-scales. The aim was to produce a safety climate tool which could be used by the FAA to profile the safety climate of different groups. Firstly, determination of the internal reliability of each of the proto-scales was undertaken, as well as item analysis within each sub-scale. The results from these analyses are shown in Table 49. This showed that the internal reliability of each scale was acceptable (α>0.70), and that removal of any of the items was not necessary (as deletion did not increase the alpha). While the internal reliability of the scales was addressed, for full scale development beyond the proto-scales described here, there is need for demonstration of test-retest reliability, as well as further validation. These steps were not undertaken due to operational restrictions on availability of personnel to undertake these final steps during the timescales of the current thesis.

Table 49.

Re-specified safety climate tool, with constituent items and internal reliability (Cronbach alpha α) for each climate scale, including Cronbach alpha (α) if item deleted.

Component 1 - Management & organisational learning (α= 0.909)		α - if item deleted
Mgt1	Managers are willing to listen to staff when it comes to the best way to do something	0.890
Mgt2	The Squadron Management encourages safe working practices	0.895
Mgt3	Line management looks out for us here	0.891
Mgt4	Managers are quick to act on safety concerns when we report them	0.892
Mgt5	The Squadron Management is good at finding the right balance between addressing safety concerns and the requirement to achieve a task	0.889
Mgt6	There is poor communication about safety issues that may affect me	0.893
Mgt7	My supervisor / manager encourages me and my team to learn from safety events	0.892
Mgt8	If a genuine error is made (resulting in an accident or near miss), management will always be supportive	0.895
Mgt9	Personal safety has a high priority here	0.892
Mgt10	The squadron management here do a good job balancing operational requirements against safety	0.893
Mgt11	Good safety behaviour is positively recognised by the line management here	0.889
Mgt13	People here are kept informed about the outcomes of meetings which address safety issues	0.895
Mgt14	My supervisor/manager encourages questions from workers about safety matters	0.892
Component 2- Normative behaviour (α= 0.819)		
Norm1	People here take shortcuts when they think there is little or no risk involved	0.745
Norm2	Taking a short cut to get work done quickly is seen as acceptable, as long as nothing happens	0.769
Norm5	Supervisors here sometimes encourage others to bend the rules or amend the procedure to achieve a task	0.772
Norm6	Supervisors sometimes sign off without checking	0.763
Norm7	People regularly get distracted when doing safety critical jobs	0.790
Component 3- Training & Experience (α= 0.830)		
Tr1	In general, supervisors are sufficiently experienced to meet the required level of supervision	0.730
Tr2	People are sufficiently experienced for the jobs they are required to do	0.720
Tr3	Everyone here is sufficiently trained to undertake their tasks safely	0.745
Tr4	There are always supervisors available to give advice	0.798
Tr5	People here are not always confident that they have the experience to do	0.782

	the job	
Component 4- Reporting (α= 0.779)		
Rep1	If people here saw an unsafe act they would report it	0.652
Rep2	Most people in my workplace report safety related occurrences	0.612
Rep3	If I thought no one would know, I would not report a colleague's error	0.761
Rep4	If people see others breaking a rule they tend to turn a blind eye	0.599
Component 5- Process/bureaucracy (α= 0.783)		
Pro1	There is too much paperwork involved with reporting safety concerns	0.769
Pro2	It is too bureaucratic to report all safety concerns	0.720
Pro3	Safety rules / procedures are only there to protect against legal action	0.736
Pro4	If people followed all the safety rules they would not get the job done in time	0.730
Pro5	Some procedures are only there to protect management's back	0.721

Ratings from items within each sub-scale were combined to create a summated rating for each respondent. These summated ratings were then used as dependent variables, and the presence of a predictive relationship explored with respect to the independent variables of function (aircrew/engineer) and rank (junior and senior ratings/junior and senior officers). This analysis was based upon a sub-sample of the complete response set collected across Studies 3 and 4 (N=483) for whom demographic information was available (detailed in Table 50).

Table 50.

Demographic details of sample (N=483) used for exploratory profiling of safety climate sub-scales.

Function	Rank
Aircrew	Junior officers N= 34
N=128	Senior officers N= 94
Engineers	Junior ratings N = 259
N=355	Senior ratings N= 96

Note: N= number of respondents

Summated ratings for the safety climate scales were checked for normality using the Kolmogorov-Smirnov test, the results of which are displayed in Table 51. All five safety climate scales showed non-normal distributions (p<0.05), so non-parametric statistics were used. The Mann-Whitney U test was used to determine differences between two independent groups.

Table 51.

Results from Kolmogorov-Smirnov test for normality.

Safety climate scale	Statistic	df	sig
Management & organisational learning	0.118	169	0.0001
Normative behaviour	0.127	169	0.0001
Training & experience	0.154	169	0.0001
Reporting	0.144	169	0.0001
Process/bureaucracy	0.082	169	0.0080

Exploration of Safety Climate Profile by Organisational Function

A key aspiration of this study was to produce a safety climate measurement tool that could discriminate between different groups, if differences in safety climate perceptions were present. Within this organisation, the *a priori* hypotheses related to differences in perceptions of safety climate between engineers and aircrew, as well as between different ranks. Although these individuals are all part of the wider military, the technical training that they receive is different, as is their immediate work environment. Aircrew operate predominately inside the aircraft before and during flight, with safety consequences likely to be immediate. In contrast, engineers perform a variety of maintenance activities prior and subsequent to the flight, with safety consequences less likely to be immediately apparent (for example, a panel left unsecured will be dangerous during flight, but probably not beforehand).

Published findings have shown differences between flight crew and maintenance crew on perceptions of management (Gill & Shergill, 2004; Patankar, 2003). The exploratory qualitative analysis detailed in Chapter 4 revealed that potential sub-cultural differences between aircrew and engineers were perceived in regard to the presence of a 'just culture' (Reason, 1997). There is, therefore, evidence from both the published literature and the current research to indicate that differences in safety climate perceptions may be expected between aircrew and engineers (performing different functions) and so the following *a priori* hypothesis was proposed:

Hypothesis 1: Ratings of the five safety climate proto-scales will vary by function.

Mann-Whitney U tests between aircrew and engineers on each of the five safety climate scales were performed, with the results shown in Table 52. Here it can be seen that there were statistically significant differences (p<0.05) between aircrew and engineer responses across all five safety climate scales.

Table 52.

Descriptive statistics and test for significant differences on each of the five safety climate scales between Aircrew (N=127) and Engineers (N=353).

Safety climate scale	Function	Mean	Standard Deviation	Mean Rank	Mann-Whitney U	Sig (2 tailed)
Management & organisational learning	Aircrew	52.0	5.8	322.48	10587	0.0001
	Engineer	45.7	7.6	202.87		
Normative behaviour	Aircrew	17.5	3.3	279.03	15942	0.0001
	Engineer	16.0	4.0	222.16		
Training & experience	Aircrew	17.8	3.1	272.62	17970	0.001
	Engineer	16.5	3.8	228.62		
Reporting	Aircrew	15.6	2.3	316.07	12817	0.0001
	Engineer	13.6	2.9	213.31		
Process/bureaucracy	Aircrew	15.9	3.6	285.35	16797	0.0001
	Engineer	14.4	3.6	224.19		

Note: the factor rating range for each scale were; *management & organisational learning* (13-65), *normative behaviour* (5-25), *training & experience* (5-25), *reporting* (4-20) and *process/bureaucracy* (5-25).

Table 52 shows that aircrew demonstrated more positive ratings (i.e. more positive safety climate perceptions) on each sub-scale than did engineers.

Exploration of Safety Climate Profile by Rank

Rank, in the military sphere, has its equivalence in the civilian world in management level, which has been shown to influence safety climate responses (Arboleda et al., 2003; Fung et al., 2005; Weyman et al., 2003). In a comparable population, Falconer (2006a) found rank to have a key influence on safety culture within ADF aviation personnel. Safety has often been described as affected by power relations (Antonsen, 2009a) which is strongly linked to management level/rank. Furthermore, within the FAA, the work undertaken by the different ranks varies considerably, with the junior ratings performing frontline engineering tasks, managed and supervised by the senior ratings. The officers are typically in charge of higher level management and planning than either junior or senior ratings. Typically, aircrew are comprised predominately of officers, and on Squadrons the most senior executive personnel (such as Commanding and Executive Officers) are aircrew personnel. Given published findings showing differences in safety climate profiles in employee groups of different management levels, the following *a priori* hypothesis was proposed:

Hypothesis 2: Ratings of the five safety climate proto-scales will vary by rank.

When considering differences by rank, given the hierarchy structures of the aircrew and engineering branches, there were no junior or senior rates of aircrew, and no officers for engineers. Given this structure, and the already observed significant differences between aircrew and engineers, significant differences in rank were only tested within each of the functional groups, and not between them. Thus, engineer ranks were junior and senior ratings, while aircrew were separated into junior and senior officers. Results from these analyses are shown in Table 53 (engineers) and Table 54 (aircrew).

Table 53.

Differences on the safety climate scales by rank for engineers (Ratings).

Safety climate scale	Rank Engineers	Mean rank	Mann-Whitney U	Sig
Management & organisational learning	Junior	167.8	10658.5	0.202
	Senior	183.1		
Normative behaviour	Junior	176.9	12238.0	0.984
	Senior	177.2		
Training & experience	Junior	188.0	98.27.5	0.002
	Senior	150.8		
Reporting	Junior	166.9	9758.5	0.002
	Senior	203.8		
Process/bureaucracy	Junior	169.6	10525.0	0.037
	Senior	194.9		

Table 53 showed that there were significant differences between junior and senior engineers on the sub-scales of *training & experience*, *reporting* and *process/bureaucracy*. There were no significant differences on the two remaining safety climate sub-scales between the different engineer ranks.

Table 54.

Differences on the safety climate scales by rank for aircrew (Officers).

Safety climate scale	Rank Aircrew	Mean rank	Mann-Whitney U	Sig
Management & organisational learning	Junior	49.1	1076.0	0.007
	Senior	68.8		
Normative behaviour	Junior	54.1	1159.0	0.279
	Senior	61.9		
Training & experience	Junior	65.1	1481.0	0.765
	Senior	62.9		
Reporting	Junior	52.9	1206.0	0.039
	Senior	68.0		
Process/bureaucracy	Junior	54.6	1261.5	0.068
	Senior	68.1		

Table 54 showed that significant differences between aircrew senior and junior officers were seen on the sub-scales of *management and organisational learning* and *reporting*, while there were no significant differences according to rank on the remaining three safety climate sub-scales.

These findings showed that of the ten pairings (5 sub-scales for junior and senior rank comparisons of both aircrew and engineers), five showed statistically significant differences, while five did not. Ratings of *normative behaviour* did not vary by rank, *management & organisational learning, training & experience* and *process & bureaucracy* showed mixed results, while ratings on *reporting* showed significant differences across ranks of both aircrew and engineers.

Testing for an Interaction between Function and Rank

The data were not normally distributed (Table 2, Appendix E, Shapiro-Wilk showed $p>0.05$ for all five sub-scales) and a two-way analysis of variance (ANOVA) to determine the interaction between the effects of rank and function was considered. However, for four of the safety climate scales (*management commitment & organisational learning, normative behaviour, training & experience* and *reporting*, Levene's test for homogeneity of variance was statistically significant ($p<0.05$), with group sizes varying at a ratio of greater than 1:5. Logarithmic transformation of the data was not able to improve results to Levene's test for homogeneity of variance, and therefore these data were not considered appropriate on which to undertake a two-way ANOVA. However, the mean normalised ratings on each of the five subscales was plotted by function and rank (see Figure6). This shows the general trends discussed previously, that aircrew ratings tended to be more positive than engineers, and that ratings from more senior rank groups tend to be more positive than those of the junior ranks. The notable exception to this is the ratings on the training/experience sub-scale, in which engineer senior ratings indicated significantly less positive responses than did junior engineering ratings.

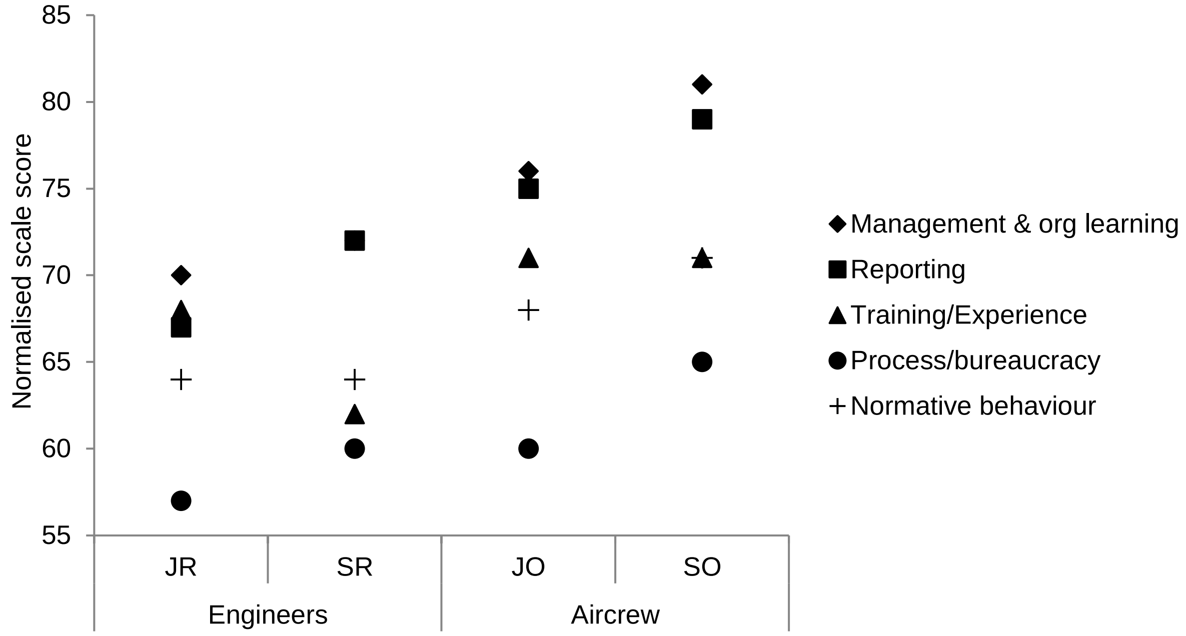

Figure 6. Mean normalised ratings for five safety climate sub-scales, by function and rank where JR= junior ratings, SR=senior ratings, JO=junior officers and SO = senior officers.

7.4 Discussion

The aim of Study 4 was to enhance confidence in the six-factor solution identified in Study 3 (Chapter 6) and explore the scope for using this to form the basis of a safety climate assessment tool for use in military aviation. The hypothesised six-factor model, based on forty-one items, did not produce a satisfactory model fit when subjected to a confirmatory factor analysis. However, through iterative re-specification, it was determined that poor model fit was predominately the result of a small number of non-concurrent items. When these were removed from the model, the fit for a five-factor model containing thirty-two items was classifiable as 'good'. The five retained factors were *management commitment & organisational learning* (12 items), *normative behaviour* (5 items), *training & experience* (5 items), *reporting* (4 items) and *process/bureaucracy* (5 items).

These components formed five safety climate sub-scales which were each shown to possess acceptable internal reliability. O'Conner et al. (2011a) suggested that identification of a reliable factor structure that is consistent with existing theory supports the claim of construct validity of the questionnaire. As the discussion in Chapter 6 detailed how these variables compared to findings from the published literature, the comparability of the constructs shown in Figure 5 to other military, aviation and non-aviation will not be repeated here, but will be integrated into the central discussion within Chapter 8. Instead, the following discussion will focus on the demographic profiles on the safety climate sub-scales, and how these findings related to established findings in the safety culture and climate literature.

7.4.1 Demographic Profiles on Safety Climate Sub-scales

Contrasts by Function

While it is generally acknowledged that safety climate is shared by groups of people, early work in the safety arena posited that this was likely to be homogenous throughout an organisation (Hofstede, 1991; Schein, 1990). However, others argue that differentiation within organisations is more realistic (Alvesson, 1985, 2002; Martin, 1992; Parker, 2000), with the possibility arising that there may be multiple sets of attitudes and perceptions toward safety in the same organisation (Antonsen, 2009a). The different social structures, work environments and structural features experienced by different groups is thought to be key to creating different perceptions amongst groups (Richter & Koch, 2004; Zohar, 2010).

It was hypothesised that the two functional groups, aircrew and engineers, might differ in their perceptions on each of the five safety climate proto-scales. This hypothesis was supported across all five sub-scales, with aircrew ratings being statistically (p<0.05) significantly more positive than those of the engineers.

When considering the constituent items of each scale, this would suggest that:

1. Aircrew considered their management to be more receptive to concerns when raised, supportive of genuine errors and likely to recognise good safety behaviour than did engineers.
2. Engineers perceived there to be more short-cut taking, less reporting of mistakes and increased distraction during safety critical tasks than did aircrew.
3. Aircrew perceived their colleagues/supervisors to be more adequately experienced and trained to conduct work safely than did engineers.
4. Engineers tended to be less positive toward the process of reporting and procedures than were aircrew.

However, it is important to consider the mean values and standard deviations for each of the scales, which generally showed positive ratings. Thus, engineer mean ratings may have been significantly less positive than that of aircrew, but they remained relatively positive.

Significant differences between aircrew and engineers in relation to aspects of *management commitment* have been identified in previous research, where flight crew and maintenance crew displayed significant differences (Dixon, 2012; Gill & Shergill, 2004; Patankar, 2003). In a comparable population of the UK's Royal Air Force (RAF), Dixon (2012) concluded that aircraft engineers had the least positive views on safety culture (Dixon's term) than other trades (aircrew, battle space management personnel). In contrast, results presented by Patankar (2003) and Gill and Shergill (2004) showed the opposite; both publications reported maintenance crew having the highest level of trust in their supervisors when compared to flight crew and engineers.

When considering differences on the *normative behaviour* sub-scale, sub-cultural differences have been found previously, with findings from a military sample (Falconer, 2006a) indicating aircrew regarding deviations from procedures to be more unsafe than engineers. However, several civilian studies have reported the opposite, with maintenance engineers reportedly having a stronger emphasis on adhering to procedures, regulatory procedures and safety practices than other occupational groups (Gill & Shergill, 2004; Patankar, 2003).

Responses to *training & experience* showed that, although mean ratings for both groups were above the mid-point, engineers ratings were, on average, statistically (p<0.05) significantly lower than those of the aircrew. A lack of training has been shown to be related to increased error incidence, and decreased confidence in one's abilities (Lawrie et al., 2006; Diaz-Cabrera et al., 2007). During the qualitative phase of this research it was aircrew who appeared to be more concerned with their eroded training and experience, rather than engineers. No comparisons could be found in the corresponding safety culture/climate literature when comparing occupational groups on the component of training, however Gill and Shergill (2004) discuss 'safety education' as an integral aspect of safety climate.

Low ratings on the *process/bureaucracy* component would suggest that respondents perceived rules and procedures as existing to protect management and apportion culpability, as well as perceiving the reporting system as involving too much paperwork. It was hypothesized that responses to this component may vary according to functional group. This was supported, with aircrew having significantly more positive mean responses than engineers.

Contrasts by Rank

It was hypothesised that ratings on the five safety climate scales would show differences by rank. In contrast with the results for function, the findings seen between ranks were rather more fragmented, and will therefore each will be discussed in turn.

<u>Management Commitment & Organisational Learning</u>

Significant differences were seen between aircrew of different ranks on this sub-scale, but not between engineers of different ranks. This would suggest, in line with deductions made by O'Conner et al. (2011b), that on this sub-scale, engineers presented a more shared view than did the aircrew.

These findings were consistent with the majority of safety climate studies that considered rank or management level (Dixon, 2012; Harvey et al., 2002; Falconer, 2006a, b; Fung et al., 2005). In civilian studies, significantly more positive views on safety climate in management or supervisor levels as compared to worker (or shop floor) staff were reported (Alhemood et al., 2004; Fung et al., 2005; Harvey et al., 2002; Prussia et al., 2004). Across these studies there was a general trend for those of more senior rank, or higher management level, to have responses that rated more positively on safety climate scales. This may reflect how individuals at different hierarchical levels conceptualise work safety (Clarke, 1999) however, Grote and Kunzler (2000) recommended caution in assuming that these more positive ratings at senior levels somehow indicate increased levels of safety. Rather, they suggested, differences between shop floor and management levels may be due to attributional bias; one expects managers to attribute more positive attitudes to themselves (self-serving) than those on the shop floor, particularly if they are the ones who oversee these safety measures.

It is also important to interpret these findings considering the management of safety within organisations where top down management initiatives (Glendon & Stanton, 2000) and uneven power relations (Antonsen, 2009a) are likely to affect the social construction of safety culture. Often management initiatives to improve safety culture are targeted at those in frontline roles, as, arguably, these are often those in which errors occur. However, these are also the personnel who have the least control over the processes and procedures (Dekker, 2014) and have the least oversight of the wider operations. Within the current organisation, the officers are typically in charge of higher-level management and planning than either junior or senior ratings. The increasingly positive safety climate ratings at higher ranks may also be due to a better understanding of what the overall organisation is aiming to achieve, along with greater insight into wider policy making and process.

Normative Behaviour

Rank was not seen to have a significant effect on ratings of this sub-scale for either aircrew or engineer respondents. This would suggest that, on this scale at least, there is a degree of shared views between ranks in each of the groups, although not between functions (as significant differences between aircrew and engineers were found). Although indirectly influenced by organisational factors, this scale related directly to the behaviours that military aviation personnel observed in colleagues and supervisors, and so possibly reflects the informal structure of the organisation. O'Conner et al. (2011a) suggested that the lack of differences that they observed between ranks may have resulted from the fact that even the senior aviators often still fly aircraft or assist with hands-on engineering, and thus remain directly involved in safety activities, which can be observed by the workforce. Given that different ranks of engineers and aircrew work closely together daily within their function (but not between functions), these close working relationships may help to create a shared view on what behaviours are considered acceptable. These findings would support those reported in Chapter 4 where there was a high degree of camaraderie, and a strong sense of responsibility for safety which occurred across individuals.

In the military, and particularly in military aviation, critical performance depends on good teamwork and coordination (Cannon-Bowers, Salas & Converse, 1993); having shared mental models (i.e. common cognitive representations of procedures, responsibilities and accepted behaviour) is particularly important for successful performance. To achieve this, there must be a degree of team learning taking place which requires ongoing social interaction and exchange between members (Veestraeten, Kyndt & Dochy, 2014). Individuals within groups undergo similar structural influences and encounter the same salient occurrences, and it is these that are thought to lead to the team members developing shared beliefs and interpretations (Van den Bossche et al., 2006). Thus, if in military groups, the influence of colleagues' behaviour is key to team learning, a positive group view of safety may be beneficial. However, as Edmondson (1999) highlights, a lack of trust in these teams may inhibit questioning of team practices, and admitting to mistakes. Therefore, a negative view of safety (or adoption of unsafe norms) may be particularly harmful in the military, as these views are likely to be reinforced through these highly cohesive groups.

Training/Experience

Senior engineers had more negative ratings on this scale than did junior engineers, whilst aircrew showed no differences according to rank. Training and experience is a key aspect of safety climate, as it is often synonymous with competence (Flin et al., 2000). These findings were in contrast with those reported by Falconer (2006a) who showed that more senior rank was related to more positive views of training aspects of safety climate. However, two explanations are proposed for this finding; firstly, in line with O'Conner et al. (2011a), it may be that the most junior engineers are generally inexperienced, thus not provide an accurate assessment of the safety climate in relation to training and they may not recognise gaps in their training or experience as more experienced (senior) individuals might. Secondly, if one considers the qualitative findings detailed in Chapter 4, engineers who were supervisors stated that increased pressure on their time meant that they were forced to spend less time supervising their sub-ordinates. It is possible that these supervisors might perceive this to lead to a lack of training or experience in junior personnel.

Reporting

Both engineers and aircrew showed rank differences about *reporting* – junior ratings evidenced the most negative ratings, followed by senior ratings. Aircrew senior officers showed more positive ratings than did junior officers. These findings corroborated those reported by Fung et al. (2005) who showed that supervisors had the strongest sense of responsibility related to reporting, with workers commonly thinking this was not their concern. Supervisors were said to have a duty to report accidents and keep good communication with sub-ordinates, which may explain these results (Fung et al., 2005). However, more senior personnel also tend to be those who are responsible for accident investigation and allocation of punitive measures, while junior personnel are, arguably, more likely to be the ones being investigated. Under-reporting has been shown to be strongly affected by the degree to which supervisors enforce safety rules while production pressure was related to more negative attitudes toward reporting and led to less accurate reporting (Probst & Graso, 2013).

Process/Bureaucracy

Aircrew of different ranks did not show different ratings on the *process/bureaucracy* scale, while junior engineer ratings were significantly more negative than those of senior engineers. This is of interest as it would suggest that junior engineers might perceive *process & bureaucracy* particularly negatively, while being the individuals who must adhere strictly to procedures in frontline tasks and potentially be best placed to report incidents or near miss events. These findings are also interesting when interpreted in relation to the findings in Chapter 4 where one of the barriers to complying with procedures was cited to be the bureaucratic burden of a vast amount of policy and regulation. The hierarchical nature of the military means that much of the communication is cascaded through command chains where senior personnel communicate changes in policy to their sub-ordinates. It may therefore be that more senior personnel have a wider understanding of policy and procedures, whereas junior personnel may not have this overview and therefore do not have an appreciation of the importance of certain aspects of the policy.

7.5 Conclusions

The aims of Study 4 were twofold; firstly to determine the validity of the six-factor solution identified in Study 3 and secondly to explore the scope for using this for the basis of a safety climate assessment tool with the capacity to profile and benchmark safety climate.

Using confirmatory factor analysis, the six-component model was compared with data from a second independent sample (meeting objective one). At the point of initial appraisal this revealed a poor model fit. Scope for re-specification of the model was determined to be appropriate. This produced a good model fit for a five-factor model, comprised of thirty-two constituent items. The five factors identified were *management & organisational learning, normative behaviour, training & experience, reporting* and *process & bureaucracy*. The confirmatory factor analysis provided the basis for the development of a set of five proto-construct scales (objective two), each possessing an acceptable degree of internal consistency (Cronbach alpha >0.70).

Finally, to address the third objective, an exploration of the discriminant properties of the set of five scales indicated the capacity to detect differences between different groups of personnel, which suggested that these proto-scales potentially possessed effective discriminant qualities. The nature and direction of differences were corroborated by qualitative findings from Study 1 and published findings. Aircrew were seen to have statistically significantly more positive perceptions of safety climate than did engineers. Differences by rank showed a general trend toward more positive perceptions of safety climate by senior personnel than junior personnel. The two notable exceptions to this were:

- No differences seen between ranks in relation to *normative behaviour*,
- Senior engineers showed less positive perceptions of *training & experience* than did junior engineers.

The foundation scale development work conducted in this study was considered to provide a robust basis for a measure of FAA naval aviation safety climate.

Chapter 8: Discussion and Conclusions

8.0 Introduction

This chapter provides an integrated discussion of the key findings from the four empirical studies, including how these findings were related to both the research objectives and the existing knowledge in the area. An overview of the key practical and theoretical contributions made by the research is followed by a summary of its strengths and limitations, and recommendations for future research.

The main purpose of the research was to contribute to the safety culture and climate literature, while providing the sponsor organisation (the RN's FAA) with practical knowledge and insight into variables impacting on safety and volitional risk taking amongst its employees. To achieve this, the research firstly set out to explore and characterise the influence of workplace culture, climate and structural elements on safety and risk decision making amongst military naval aviation personnel. Secondly, from the perspective of organisational learning, the research aimed to consider how to support enhanced resilience to failure through exploring the scope for developing sector-specific, quantifiable leading indicators with the capacity to detect weaknesses in safety climate and identify priorities for improvement. The study population of FAA personnel was predominately comprised (by proportion) of two specialisations; aircrew (responsible for piloting and navigation of the aircraft) and engineers (responsible for the routine maintenance and repair of aircraft and associated technology/ancillary equipment). The research approach was based on established theory and practice, informed by contextual insight, and grounded in employee experiences. The approach purposively adopted a sequential mixed-method design and utilised a consolidated theoretical framework for conducting the empirical studies.

8.0.1 Summary of empirical chapters

Shortcomings with safety climate tools developed in military aviation settings were identified (Chapter 2), specifically that they utilised top-down approaches to characterising important safety culture/climate components, which did not appear to stand up to statistical scrutiny. The current research sought to address these shortcomings through adoption of contemporary approaches evidenced within civilian aviation safety climate studies, which have emphasised a bottom-up, contextualised approach. Furthermore, novel investigation into comparative ranking techniques considered the utility of employing ranking methods to inform organisational safety priority setting, complementary to more traditional safety climate measure development using rating scales.

The aim of Study 1 was to explore participant accounts of norms, values, attitudes and behaviour in relation to safety, in order to inductively generate insight into core influences on workplace safety culture in the FAA. This aim was met through adoption of a qualitative approach to data generation and analysis. Seven themes were considered to be the most salient to military naval aviation participants, including *policy & procedures*, *pressure*, *leadership & safety ownership*, *individual & collective responsibility*, *communication*, *training & experience* and *organisational commitment*.

The aim of Study 2 was to elicit FAA personnel perspectives on priorities for intervention to enhance safety culture, and secondly to determine the relative merits of widely used alternative ranking techniques. The latter was of interest with respect to ease of use, the utility of the output and to determine whether the order of priority elicited was prone to vary between methods. Comparison of the performance of Q-Sort, direct ranking and the method of paired comparisons showed that while the method of ranking did not appear to significantly affect the rank order produced, the method of paired comparisons afforded a more nuanced view of the findings. However, participants found it the most tedious and frustrating to complete. Three issues were identified as potential priorities for intervention; *human resources* (staffing levels)*, priority of safety* and *competency & experience.* Future work is required to build on these findings before a ranking tool could be considered for widespread use in the organisation.

Studies 3 and 4 built on findings from Studies 1 and 2, with the aims of quantitatively identifying a finite set of components which characterised headline influences on workplace safety climate through both exploratory (Study 3) and confirmatory (Study 4) methods, using independent samples. These aims were partially met, with a six-component model identified using PCA. The resultant CFA showed a poor model fit with this six-component model, however, re-specification of the model resulted in a good model fit for a five-component model, containing thirty-two constituent items. The five components showed acceptable internal consistency and the capacity to detect differences between different groups of personnel.

The findings from these empirical chapters, and the learning which is provided by these in relation to the existing literature are discussed further in the following sections.

8.1 Discussion and interpretation of Key Findings

8.1.1 Factors Influencing Safety and Risk Decision Making in the Military Naval Aviation Context

The empirical findings revealed a number of key influences on safety and risk decision making amongst military naval aviation personnel. These were interpreted through reference to published findings within the respective chapters, with a core focus on aviation and other high risk industries. The key influences from the current research are discussed in this chapter against key influences reported in studies from aviation (Table 55) and other high risk industries (Table 56).

The Influence of Management on Safety

The role of managers as a key influence on employee safety behaviour was identified in Study 1, with reference to issues of *leadership and safety ownership*. Findings from Study 3 complemented this in revealing the latent factor, *management commitment and organisational learning*. Interestingly, findings from Study 2 indicated that personnel did not rank *management commitment* as a particular priority that needed addressing in their workplaces, which might indicate a relative strength of this dimension in the FAA.

The findings that management play a key role in setting the cultural profile of safety is unsurprising given its universal identification within safety culture and climate research (see reviews by Choudrey et al., 2007; Clarke, 2000; Farrington-Darby et al., 2005; Flin et al., 2000; O'Conner et al., 2011b; Seo et al., 2004; Weigmann et al., 2004). Indeed, while naming conventions exhibit variability, irrespective of the method of enquiry, all studies reviewed contained at least one factor with management as a focus. While detection of the key influence managers on safety culture and climate was therefore expected, there appeared to be a number of particular ways in which this influence manifested in the military naval aviation context. For this discussion, these have been grouped into three main areas:

a. Managers as role models,
b. Managers as conduits for organisational learning,
c. Managers as priority setters.

<u>Managers as Role Models</u>

The theme of *leadership and safety ownership* (Study 1) was sub-divided into frontline personnel perceptions of (i) supervisors and (ii) senior managers, which revealed greater articulation (by volume) and depth of discussion about supervisors than senior managers.

While the motivation and rhetoric of senior managers tended to be viewed rather cynically, supervisors were widely portrayed by personnel as playing a key role in influencing subordinate safety behaviour, both positively and negatively. In this way, supervisors were interpreted as setting the 'tone' of safety, instructing and influencing sub-ordinates about the value of safety related behaviour.

Examples cited in Study 1 reflected several informal mechanisms; how supervisors established and reinforced 'norms', widely accepted ways in which more junior (or less experienced) staff were expected to work. Echoing findings reported in Buttrey et al.'s (2010) study of US aviation personnel, several examples were cited which described how short-cuts could be introduced into the work process and transferred from more experienced personnel to their sub-ordinates through informal teaching/instruction methods. Examples were also given of more formal management behaviours, such as ensuring compliance with wearing protective equipment, and adhering to policies and procedures.

Table 55.

Comparison of aviation safety culture models after confirmatory factor analysis with the results of the current study.

Authors	Current study	Onen (2016)	Mearns et al. (2013)	Buttrey et al. (2010)	Block et al. (2007)	Kao et al. (2009)	Evans et al. (2007)
Sample	UK Military aviation	Turkish aviation maintenance repair	European air traffic control	US Navy and Marine Corps	US Flight Crew	Taiwanese cabin crew	Australian civilian pilots
Description	5 factors, 32 items	6 factors, 33 items	3 first order factors, 6 second order factors, 30 items	2 factor model with 12 items	2 first order factors, 2 second order factors which predicted safety outcomes	6 factor model, 23 items	3 factor model, 18 items
Factors (Common)	Management commitment & organisational learning	Commitment	Involvement in safety (management and team)	Personnel leadership	Proactive management (relational supervision)	Management commitment to safety	Management commitment to safety
	Normative behaviour	Behaviour	Prioritisation of safety (support & commitment)	Integration of safety and operations		Rule compliance Crew member participation / involvement	
	Training & experience	Awareness			Proactive management (training effectiveness)		Safety training
	Reporting	Information Justness	Reporting & learning (support & commitment)		Organisational affiliation (communication)	Accident investigation	Safety communication
Factors (Novel)	Process/ bureaucracy						
		Adaptability					
						Cabin work environment	
							Equipment maintenance

Table 56.

Comparison of other high risk sector safety culture models after confirmatory factor analysis with the results of the current study.

Authors	Current research	Huang et al. (2013)	Griffin & Neal (2000)	Pousette, Larsson & Torner (2008)	Olsen (2008)
Sample	Military aviation	Remote utility companies	Manufacturing and mining	Construction	Norwegian healthcare
Description	5 factors, 32 items	Second order hierarchical factor model, 29 items	5 factor model of safety climate, number of items not stated	Second order model, general safety climate as first order	Unit (7 factors) and hospital level dimensions (3 factors)
Factors (Common)	Management commitment & organisational learning	Safety proactivity (management) Financial investment Supervisory care	Management values	Safety management	Supervisor/manager expectations Management support
	Normative behaviour	Participation encouragement Safety straight talk	Safety practices	Safety priority Workgroup safety involvement	Teamwork-within unit Teamwork across units
	Training & experience	General training	Safety training		
	Reporting		Safety communication	Safety communication	Organisational learning Communication Non-punitive response to error
Factors (Novel)	Process/ bureaucracy				
		Trucks and equipment	Safety equipment		
		Field orientation			
		Schedule flexibility			
					Staffing Hospital handoffs and transitions

Both positive and negative aspects of this role model behaviour were captured in Study 3 where items such as 'The squadron management encourages safe working practices' and 'Good safety behaviour is positively recognised by the line management here' loaded onto the component of *management commitment and organisational learning*, while negative items such as 'Managers turn a blind eye to rule bending' and 'Supervisors sometimes sign off work without checking' loaded onto the *normative behaviour* component. The items contained within *management commitment and organisational learning* were interpreted as formal safety behaviours while items contained within *normative behaviours* appeared to be those that occurred outside of the formal management process; those that happened when 'no one was watching'.

Managers have been reported as playing an important role in communicating expectations and defining acceptable safety by a wide range of sources (see for example Conchie et al., 2013; Flin & Yule, 2004; Michael et al., 2006; Thompson et al., 1998). This has widely been assumed as an important safety leadership component, in part because it has been found to be a good predictor of desired behaviours amongst employees (Michael et al., 2006) and has been linked to the occurrence of fewer injuries (Bahn, 2013). Indeed, leadership style is almost universally regarded as having a direct influence on employee safety behaviour (Martínez-Córcoles et al., 2012).

A widely-encountered facet of safety culture/climate research focuses on the nature and quality of leader-member exchange (LMX), i.e. the relationship between employees and their managers/supervisors (Yagil & Luria, 2010). Formally, managers fulfil the role of implementing policy and procedures and subsequent compliance monitoring (Hale & Borys, 2013), thus having a direct influence over the practices that occur on the front line (Bahn, 2013). However, this might also extend to more subtle forms of communication, such as not wearing PPE when required or ignoring employee safety transgressions, each of which may infer the level of safety commitment of the manager to employees. In military teams the quality of LMX has been shown to be affected by rank (recruits and non-commissioned officers tended to have higher quality relationships than recruits and officers), arguably as a by-product of the different responsibilities of each group (Maksom & Winter, 2009).

Managers as Conduits of Organisational Learning

A further way in which managers were perceived to influence safety amongst military aviators was through their handling of accident and incident reporting and investigation, as well as how they facilitated safety related communication between senior management and frontline personnel. This role as a conduit for communication has been identified as a key component for fostering a workforce that reports errors, near misses and unsafe conditions (Antonsen, 2009b; Conchie et al., 2013; Reason, 1997). In this context, management style and practices can operate as either facilitators or barriers to organisational learning.

In Study 1 participants described how, what they characterised as, good managers were seen to deal with issues such as errors, accidents and incidents in such a way as to allow subordinates to feel confident about raising safety concerns in the future. Specifically, whether personnel were happy to admit to an error was often said to be reliant on perceptions and beliefs regarding how their supervisors had reacted to similar situations in the past. This was corroborated in Studies 3 and 4 where items such as 'Managers are quick to act on safety concerns when we report them' and 'If a genuine error is made (resulting in an accident or near miss) management will always be supportive' were represented on the *management commitment & organisational learning* component. Table 55 and Table 56 reflect similar components; Huang et al. (2013) reported similar features within their safety climate component of *supervisory care* (e.g. 'Gives me positive feedback when I perform safely', 'Discusses ways to improve performance after non-routine or unusual jobs' & 'Effectively communicates my concerns to the company'). In aviation, Block et al. (2007) referred to *relational supervision* (containing items such as 'My supervisor can be trusted' & 'My suggestions about safety would be acted upon if I expressed them to my supervisor').

The need for, and benefits of, a fair and consistent approach to dealing with errors was highlighted by Reason (1998) and was further recognised in the Nimrod Review (Ministry of Defence, 2009). Named a just culture, this was characterised as a situation where people were encouraged and supported to provide safety-related information, with a clear distinction made between acceptable and unacceptable behaviour (Reason, 1998). Just culture was posited in response to a previous shift in focus from a blame culture to a no blame culture (Dekker, 2009; Reason, 2000). The first of these is generally acknowledged to be excessively punitive, but the latter is said to be equally undesirable as it could endorse potentially reckless acts that require strict sanction (Dekker, 2009).

Conceptually, a just culture approach is meant to balance learning and improving with accountability; however, it’s application is thought to likely encounter some practical difficulties. Fundamentally this hinges upon the assumption that what is ‘just’ can be established in some objective manner. As Dekker (2009) noted, establishing such can prove challenging under a wide range of circumstances. Moreover, it can be important to consider issues of volition (did the person know what they were doing might lead to negative consequences). A volitional act, with a complete understanding of the consequences contrasts with well-intentioned but inappropriate acts involving an incomplete understanding of causality.

While in extremis, recourse to the legal system may determine whether an employee's actions prior to an accident were reasonable, more often it is the senior managers and leadership within an organisation or profession who determine this. As Antonsen (2009a) noted, the power relationship, routinely combined with a reluctance to deal with deeper causal factors, can lead to a risk that managerial orientation is self-serving and prone to lay accountability on frontline individuals. Where such bias is transparent, or believed to be present, motivation to report errors or safety issues and participate in safety improvements may be affected. In marked contrast to what authors such as Reason seem to have proposed, it is also apparent that some organisations have interpreted calls for a just culture as justification for a compliance culture i.e. with justice referenced to determination of (non)compliance with rules and procedures. Therefore, calls for a just culture are important, but are not a panacea and require significant management and transparency of the process.

Managers as Priority Setters

A further way in which managers were seen to have an impact on safety in this research was through their role in setting operational priorities, indicating to employees the relative importance of safety in relation to other organisational goals. In Study 1 this manifested in discussions about the *pressures* being faced by front-line personnel, particularly in situations where there was strong time sensitive performance pressure from external sources (e.g. combat or exercise situations). This tentatively indicated the tendency to sacrifice personal safety to deliver what personnel viewed as their primary objectives (operational capability). Furthermore, in Study 2, *priority of safety* was ranked as a salient aspect in need of prioritisation for improvement.

The findings from Study 2 corroborated those from Study 1, where personnel described that although senior managers were observed to cite safety as the dominant discourse, this was often incompatible with the practicable constraints imposed by the reality of every-day work. Normal work was claimed to be characterised by a limited availability of resources, which was in notable tension with the espoused expectation that work teams would maintain, if not improve, their operational output while maintaining safety.

These findings were further supported by those from Studies 3 and 4, where several items related to aspects of priority setting (e.g. 'The squadron management are good at finding the balance between addressing safety concerns and the requirement to achieve a task' & 'The squadron management here do a good job balancing operational requirements and safety') formed part of the *management commitment and organisational learning* component.

The above might indicate for the FAA that the role played by managers in setting organisational priorities should be carefully monitored and managed, particularly with respect to the implicit messages that their actions can transmit to those working in frontline roles. Where manager/supervisor priorities and actions explicitly or implicitly induce unsafe work practices, particularly where this contrasts with safety rhetoric at senior management levels, it is foreseeable that this could sponsor confusion, cynicism and mistrust at the frontline. Supervisors control how locally allocated resources are applied and how organizational messages are translated into daily activities (Mearns et al., 2004; Simard & Marchand, 1994), however this is unlikely to be the root of the problem; rather it is likely that tensions and trade-offs become most visible at these management levels (DeJoy, 1994).

In the published literature, senior management is held to be key to supporting frontline managers through ensuring sufficient policies and resources are in place (Tappura et al., 2017) while resource allocation has been acknowledged as having a strong influence on how safely people can work (Guo et al., 2016). Essentially, by determining where resources are allocated and setting safety priorities, senior managers act as choice architects, creating the context in which line managers/supervisors are influenced to make decisions that involve safety and risk (Thaler & Sunstein, 2008). By making an option (in this case a 'safe' or lower risk option) the default choice, easy to undertake and supported by positive incentives, people can be influenced to make that decision above other (less safe/higher risk) choices (Thaler & Sunstein, 2008). However, this choice architecture created by senior managers in organisations exists within a bounded world, impacted by, for example, government budget allocations, national security priorities and political pressures.

The importance attributed to management behaviour on safety within the FAA echo findings from both military aviation and commercial aviation (detailed in Table 55) as well as other high risk industries (see Table 56). Managers in those sectors culturally placed emphasis on safety as an overriding priority, along with managers in the oil and gas (Kvalheim & Dahl, 2016) and mining (Weyman et al., 2003) sectors. However a similarly strong management emphasis on safety was not noted in studies completed within industries such as gas distribution (Blazsin & Guldenmund, 2015), commercial fishing (Brooks, 2015), grain processing (Walker, 2010) and steel manufacturing (Nordlof et al., 2015).

Policy, Rules and Procedures

The theme/component of *policy and procedures* was characterised throughout the current research findings in a number of ways. In Study 1, operational personnel described rules and procedures in ways which indicated high cultural legitimacy; i.e. they were seen as necessary for dealing with complex systems such as aircraft and so compliance was considered important. Published findings from similar (aviation) studies are congruent with the view that there may be an underlying cultural acceptance about the importance of procedures across the aviation sector, with both Patankar (2003) and Hopkins (2010) characterising aviation employees as rule followers. Kao et al. (2009, Table 55) reported a similar component (*rule compliance*).

Despite this, there was a widely-encountered perception (Study 1) that within the FAA there was an ever increasing volume of policy and procedures that was in a constant state of flux. Coupled with the commonly held perception that this was driven by a focus on accountability by senior management, concern was raised by personnel that burgeoning procedures were becoming overly burdensome. This has previously been reported to raise questions of practicality and workability of procedures, and has the potential to reduce subsequent attention to cumbersome documents (Drury & Johnson, 2013). Some corroboration of this was provided within Study 3 where two items loading onto the component of *process/bureaucracy* related to the perception that rules and procedures were only there to protect against legal action or protect management's back. This suggested that there might be a tension between the acceptance of procedures and the perceived increase in accountability described by personnel. When compared to findings contained in Table 55 and Table 56, no studies explicitly appeared to have characterised a similar dimension, however similar concepts are considered by Power (2008) in relation to secondary risk management.

Burgeoning proliferation of policy and process can be seen by employees as passing the responsibility and accountability (for non-compliance) to frontline employees, and can give rise to cynicism regarding the purpose of poorly configured policy and procedures and the motivations of their authors (Szymczak, 2014). Bureaucratic routines (such as making employees sign to say they have read policy or completed certain procedures) have been found to be an inadequate measure to ensure appropriate knowledge (Dahl, 2013) or assure competence, raising the question of their utility beyond audit purposes. In contrast, making policy and procedures relevant and easy to comply with (Hale & Borys, 2013) has been described as key to facilitating compliance, again reflecting aspects of Thaler and Sunstein's (2008) choice architecture.

The research did not consider different types of procedures/policy; however it is reasonable to assume that there may be some which were seen by employees as essential, and others that were seen as sacrificial. Furthermore, this may vary with context and prevailing conditions/priorities, thus could be perceived as relatively fluid. Nevertheless, the importance of procedures and policy in aviation organisations is likely to be enduring; the very nature of the work requires a degree of proceduralisation, whether when piloting the aircraft, or undertaking maintenance on it. The presence of fewer, high quality procedures are said to be important, as an increase in volume of rules and regulations to cover every aspect of work is ultimately more likely to lead to less comprehension amongst employees (Laurence, 2005). The importance of these findings for the FAA lay in ensuring that adequate procedures were in place to guide work, but that this was balanced with the importance of ensuring additional procedures were not seen as the default option to tackle issues which might more appropriately be addressed through other means (such as organisational or structural influences). More highly engaged employees have been shown to be more motivated to work safely (Nahrgang, Morgeson & Hofmann, 2011); enabling employees to be involved in the review and writing of policy and procedures may be one such way of engaging employees in this process.

Reporting Incidents and Unsafe Conditions

Personnel orientation to reporting of incidents and unsafe conditions followed a similar pattern as that described for policy and procedures. While qualitative findings indicated that personnel were aware of the need to report errors, accidents and incidents (Study 1), when relevant questionnaire items were analysed quantitatively (Study 3), items relating to the belief that following procedures/reporting safety incidents was important were observed to cluster together (*Reporting*) but appeared to be discrete from items relating to barriers/disincentives to reporting (*Process/bureaucracy).* These findings suggested that there might be a potential difference between whether personnel believed that reporting was important, and their perceived ability to overcome barriers/disincentives to report errors and safety issues.

There was considerable variation across comparison studies (Table 55) with respect to incident reporting, with only Mearns et al. (2013) referring directly to reporting. Other studies referred to *communication* (Block et al., 2007; Evans et al., 2007), or *accident investigation* (Kao et al., 2009) which arguably overlap with the current study's concepts of *management commitment & organisational learning*. When considering findings from other high risk industries (Table 56), aspects of reporting appeared to be more often captured under the umbrella term of *communication* (Griffin & Neal, 2000; Olsen, 2008; Pousette, Larsson & Turner, 2008) and *organisational learning* (Olsen, 2008). This is perhaps unsurprising, as reporting of safety incidents and errors is a form of communication by which employees tell managers about safety issues and hazards that they face.

Within wider aviation research, there have been claims that, despite an industry-wide drive toward confidential and non-punitive reporting systems, a high degree of under-reporting of safety occurrences remains (Gilbey et al., 2015). Organisational barriers such as insufficient time (Wiele & Rantanen, 2015), inadequate information technology, workplace barriers such as peer influence and bureaucracy (Wiele & Rantanen, 2015) and cultural barriers such as fear of consequences/retribution (Johnson, 2002), a lack of competence and lack of knowledge (Jausen et al., 2017) have, variously, been cited as underlying causes of under-reporting.

A number of these concerns were found to be present in the focus group accounts (Study 1), notably a fear of stigma (being ridiculed as either a trouble-maker or incompetent) and slow and complicated reporting processes. Published accounts tended to cast organisational barriers as significantly more likely to negatively impact on reporting behaviour than either workplace or individual factors (Jausen et al., 2017), despite common management beliefs to the contrary. Such barriers are not unique to aviation, reporting systems in healthcare have also often been cited as complicated and providing inadequate/inappropriate feedback (Lawton & Parker, 2002). Ensuring ease of use of the reporting system (Jausen et al., 2017) was described as a key factor to maximising use of safety occurrence reporting.

These findings might suggest that the FAA should focus on ensuring that the structural and social context within the organisation is amenable to supporting reporting.

Focusing on making reporting easy, standardising the way in which different functions (such as aircrew and engineering) address errors and therefore inculcate a just culture would appear two practical important areas for the organisation to focus on improving through removing barriers to reporting and potentially improving the quality/quantity of reports.

Training and Experience

A fourth influence on safety and risk decision making which was identified through the empirical studies was that of *training and experience*. Discrimination between training and experience was made in Studies 1 and 2 with aircrew, in particular, suggesting that getting enough hands-on experience in airframes was key to affording them confidence in their roles - particularly in unusual or exceptional circumstances. During the initial phases of Study 2, flight safety subject matter expert advisors maintained that training and experience were two discrete safety dimensions, arguing that an operative could be fully trained, but not have the experience to complete a task safely and therefore be considered competent. This was corroborated by the study participants who appeared to clearly discriminate between training and competency/experience in relation to whether they were evident in their workplace (see Figure 4 in Chapter 5).

However, in Study 3 items related to training and experience were observed to cluster on the same factor (*training/experience*). It is possible that this reflected the underlying method used for each study. In Study 3, the PCA effectively clustered items which were answered in similar ways to each other, while separating them from other clusters of items. Thus, responses to items relating to training and experience may have been answered more similarly to each other than compared to how items on other components (such as *management commitment*) were answered. However, the qualitative and comparative methods used in Studies 1 and 2 may also have allowed for greater levels of discrimination between training and experience, even though these might be seen as related concepts. This reflects the importance of employing mixed methods in studies of safety culture and climate in developing a holistic perspective.

Four of the six aviation comparison studies (Table 55) contained a factor related to *training.* Findings reported by Mearns et al. (2013) suggested that items related to *reporting* and *learning* were related in their study, being co-located on a single factor. Block et al. (2007) titled their component *training effectiveness* (containing items such as 'We receive an adequate amount of safety training' & 'I am adequately trained to conduct all of my job duties and responsibilities'). *Training* was also identified as an important safety culture/climate component in studies of remote utility companies (Huang et al., 2013) and manufacturing/mining sectors (Griffin & Neal, 2000) whilst not in studies within the construction (Pousette, Larsson & Torner, 2008) or Norwegian healthcare (Olsen, 2008) sectors. However, it is plausible that items relating to training may have loaded onto other factors in these studies, however few of the publications detailed a full list of all items, thus limiting the degree to which comparison with the current findings could be undertaken.

A focus on both training and experience has practical implications for the FAA in relation to how these may influence safe behaviour and skills of employees. Ensuring that employees are well trained has two impacts on safety; firstly, a lack of training has been shown to be related to increased numbers of errors, and thus can directly impact employee safety behaviour. Secondly, training is likely to lead to increased confidence and the ability to cope in high pressure or unusual circumstances (Lu & Shang, 2005) which is sometimes known as resilience (Fernandez-Muniz et al., 2007). Used to inform employees of risks in the workplace, a higher frequency of safety training has been positively associated with more favourable safety climate ratings (Lu & Shang, 2005). However, experience may also impact on behaviour, either encouraging safe work practices or encouraging shortcutting when experience is seen as more important than rule following.

Performance Pressure

Performance pressure (essentially, time pressure arising from organisational goal fulfilment with linkages to sufficiency of resources) was identified as a discrete theme in Study 1. In Study 2, similar components were contained within two separate dimensions, *priority of safety* and *human resources*. Of these, *human resources* was ranked least evident of the dimensions, after *priority of safety* (Study 2), potentially indicating that these were seen by participants as requiring high prioritisation for improvement. Study 3 appeared to corroborate the salience of *human resources* as an influence on safety as items relating to this clustered on a single component containing four items. Items reflecting other sources of pressure loaded variously onto the components of *normative behaviour* and *management commitment & organisational learning* (Study 3). It is postulated that this dispersion of aspects of pressure across these components may reflect where these sources of pressure may manifest. For example, some pressures come from colleagues and peer pressure (*normative behaviour*) whilst others are created by, or related to, management roles (*management commitment & organisational learning*).

When considering studies from comparable industries (Table 56) both Griffin and Neal (2000) and Huang et al. (2013) identified *equipment* as a separate safety climate dimension. Although a lack of equipment (resources) was identified as influencing safety in the current research (Study 1), questionnaire items relating to equipment were not retained in Study 3. It may be that shortages of equipment could be more integral to some naval aviation functions (such as engineers) than others; if so, this may have affected the importance which respondents attributed to the questionnaire items. In contrast, equipment effects on safety are likely to be particularly more salient to Griffin and Neal and Huang et al.'s sampled populations (manufacturing/mining and utility companies respectively).

The pressure to remain operationally effective in the face of resource shortfalls could be said to create potential conflict between achieving operational objectives and occupational/employee safety objectives. While the safety and integrity of the aircraft presented as being of the highest priority amongst participants, the main concern was that FAA personnel might be confronted with conflicting demands to achieve time pressured end-states, but also work safely.

Noted across a variety of industries (Christian et al., 2009; Mearns et al., 2004; Nordlof et al., 2015; Weyman & Clarke, 2003), where goal realisation is the principle criterion for the front line, it is foreseeable that safety policies and rules may get violated (Westrum & Adamski, 2009) with reduced attention to those that impede progress (Bosak et al., 2013). Conflict between safety and output can originate at both the organisational level (balancing expenditure and resources) and the individual level (short term cost-benefit of safe behaviours). Therefore, the importance of these findings to the FAA lay initially in identification of areas of pressure (such as a lack of resources) and then consideration of how these may influence employee safety behaviour. Findings from Study 1 indicated that risks to the aircraft were seen as particularly unacceptable (potentially due to their role in operational capability) while personal safety was not cited as having such dominance. Furthermore, some risks (e.g. when conducting search and rescue to save a life) were seen as more acceptable than others (e.g. taking an unnecessary risk in a training environment was seen as less acceptable).

Table 55 and Table 56 indicated that few of the comparison studies explicitly identified a similar component to *human resources*, with the exception being Olsen (2008). This author reported a factor termed *staffing* (containing items such as 'We work in crisis mode trying to do too much, too quickly' & 'We have enough staff to handle the workload'). Olsen (2008) suggested that this factor was not common across all healthcare facilities which were surveyed, but was identified in those which had recently undergone cost cutting measures, and therefore were likely to be understaffed.

Individual and Collective Responsibility

Identified initially in Study 1, it was apparent that a key motivator amongst military naval aviators to work safely was an acceptance that all individuals within the FAA were responsible for safety. This presented as being driven by a strong sense of personal responsibility for one’s colleagues and as such was therefore interpreted as camaraderie. Work teams (of approximately six to ten individuals in many cases) were described as watching out for each other's personal safety, to make sure that they did not put aircraft and other personnel at risk. The salience of this construct/dimension was corroborated in Study 2, where *individual responsibility* was consistently ranked most evident of the dimensions. Nevertheless, it was considered important to ensure that although FAA individuals felt responsible for safety, that this should not only apply to frontline personnel. The lack of senior management participants in the current research did not allow generalisation of findings to this group, therefore it is unclear whether this perceived importance of *individual responsibility* extended to senior management personnel. This was identified as an important consideration for future research.

It seems reasonable to speculate that the high levels of perceived personal responsibility for safety may reflect the visible link between behaviour and consequence in the aviation context. Aircrew were directly responsible for the safety of personnel on-board their flight, while engineers were responsible for the aircrew, and both have responsibility for the safety of the public. The consequences of poor safety are perhaps particularly obvious to these personnel. Similar findings of personal responsibility for safety were reported amongst professions such as fire-fighters (DeJoy et al., 2017) and paramedics (O'Hara et al., 2014).

When items which related to aspects of individual responsibility were included in Study 3 ('People I work with think safety is very important' and 'People here are only interested in safety aspects of their own jobs, not other people's'), these were removed due to displaying high skew values (Ferguson & Cox, 1993). It was noted that all items relating to individual responsibility were highly positively skewed, and on consideration of the distribution of responses on these items, it was noted that there was very little variance in the data, i.e. there were very few people who rated these items negatively. Critical consideration of findings related to the influence of individual and collective responsibility over safety within this research may lead to concluding that this is a cultural variable, on which many of the personnel in the organisation agree. Support for this lay in Study 1 findings, and the high levels of agreement in Study 2 regarding the saliency of *individual responsibility* for safety. The positively skewed questionnaire items reflecting *individual responsibility* also demonstrated high kurtosis in responses, indicating that there was a high level of agreement amongst respondents to these items on the questionnaire (Chapter 6), which may reflect a high 'shared' view on these items (i.e. most personnel answered these questions in the same way).

However, it is also possible that the items and dimension of *individual responsibility* could be susceptible to social desirability bias. The group setting of the qualitative phase (Study 1) may have motivated personnel to express opinions that were in line with what would be expected of them by the organisation, rather than true perceptions. The external referent nature of the discussions and items (i.e. referring to the behaviour of others, rather than oneself) was used in an attempt to moderate this effect, but social desirability bias cannot be ruled out. However, the ranking responses (Study 2) and questionnaire responses (Study 3) were anonymous, and so the impact of social desirability is arguably less likely in these studies than in the focus groups (Study 1).

On balance, findings from the wider safety culture/climate literature would support the conclusion that the concept of *individual responsibility* is likely to be an important influence on safety within the FAA. Similar themes have been described variously as personal involvement, individual responsibility or individual empowerment (Choudrey et al., 2007; Clarke, 2000; Farrington-Darby et al., 2005; Seo et al., 2004). In a military organisation such as the FAA this could reasonably be expected to motivate behaviour; indeed trust, comradeship, a sense of belonging (Guzzo & Dickson, 1996; Veestraeten et al., 2014) and citizenship behaviour (Case-Campbell & Martens, 2009) are held to characterise military teams. Furthermore, if naval aviation employees feel supported within the work environment (i.e. colleagues will help and 'back you up'), it is likely to have a positive effect on safety performance, as has been reported within healthcare populations (Turner et al., 2012). Parallels between military and healthcare contexts include situations where time critical demands may exist in opposition with safety (for example, search and rescue/humanitarian activities and emergency care respectively). Employees who have a high level of trust in each other (Kelly et al., 2015) and groups with high cohesion (Luria, 2008) have been shown to demonstrate more positive safety climates and good safety compliance, as employees felt comfortable to share ideas, knowledge and support (Geller, 1994; Geller, Roberts & Gilmore, 1996; Yagil & Luria, 2010).

In the FAA personnel typically train, live and work together in relatively close proximity (either aboard ships or on dedicated airbases) and the high degree of social interaction which is likely to arise might arguably lead to higher levels of care for each other's wellbeing and safety (supported by findings reported by Burt et al., 2008). Equally, however, negative norming effects may also potentially occur. Personnel can learn bad habits from co-workers, they can conform to more risky work practices where these are norms and high group cohesiveness can over-ride an individuals' willingness to admit to errors or speak up against group norms (Falconer, 2006b). The implications for the FAA are that positive and negative safety behaviours may equally be likely to be shared and spread within the population, and once set in, these may be difficult to alter at an organisation level. Therefore, it might be important to encourage the positive aspects of camaraderie/cohesiveness while minimising the potential negative effects.

Organisational Commitment

A theme identified in Study 1 that has received little attention within the safety culture and climate literature was that of *organisational commitment*. FAA personnel were noted often to compare themselves favourably with other branches of the UK Armed Forces, and expressed a high number of comments relating to pride at belonging to the FAA. Although the frequency with which this theme appeared within the focus group data suggested it to be one which was widespread (and therefore very likely to be a cultural feature) it was interpreted as relating to the broader reference of pride and belonging to the FAA, rather than necessarily limited to safety *per se*.

While most of the comparative studies (within Table 55 and Table 56) did not identify a similar component, Patankar (2003) in his study of civilian aviators reported *pride in company* while Block et al. (2007) reported finding *organizational affiliation* as a safety climate component. It is possible that, as this component is not strictly focussed on safety (but rather on a more general organisational concept), that safety focussed studies might be unlikely to identify it. The anecdotally strong military ethos, coupled with informal rivalry between the Defence aviation organisations (the FAA, the RAF and the Army Air Corps) may underpin the identification of this as a separate component in the current research.

While a single item within Study 3, intended to reflect the concept of *organisational commitment* (People here take pride in doing things safely), was initially found to load weakly onto the *normative behaviour* component (Study 3) it was not retained in the six-factor exploratory model. The item exhibited high positive skew characteristics (although it did not warrant immediate removal) which suggested that there was relatively little variation in employees' responses (with positive views for most respondents). The implications of high levels of personnel commitment to the FAA is suggested to be two-fold. On a positive note, commitment is important in relation to improving employee engagement (Nahrgang et al., 2011), however this may also encourage peer pressure as employees attempt to 'fit in' to the organisation.

Summary of Factors that Influence Safety and Risk Decision Making in Military Naval Aviation

In summary, there were six main factors found to influence safety and risk decision making within the FAA. Each was interpretable with reference to published findings and the comparisons drawn in Table 55 and Table 56 would suggest that there are some commonalities between the safety culture and climate components/factors detailed in the current research, both across aviation studies and other high risk industries. However, the unique factors reported also give insight into particular issues which different populations may consider important to safety.

8.1.2 Indicative Effects of Function and Rank on Perceptions of Safety Climate and Safety Culture

In addition to determining key influences on safety and risk decision within the FAA, the research set out to explore the influence of the structural and socio-technical environment on ratings of safety climate. One school of thought, principally within foundation work in this area, held that culture and climate within organisations was homogenous (Hofstede, 1991; Schein, 1990) while others have posited that differentiation between groups, i.e. sub culture/climate differences within organisations is more realistic (Alvesson, 1985, 2002; Frost et al., 1991; Martin, 1992; Parker, 2000; Pidgeon, 1998). When considering safety climate Zohar (2014) argued that the structural features of the organisation were key to creating shared perceptions, and that these structural features might differ according to, for example, job role or position in the organisation. Thus, the current research sought to explore whether different cultures or climates might arise as different groups evolve and establish norms and ways of working in relation to risk in response to local proximal social arrangements arising from organisational structures. It was important that during development of a safety climate tool for the FAA, that the scales could demonstrate their ability to discriminate between groups who differed in their views on safety climate.

Qualitative Findings

Given the exploratory nature of Study 1, no systematic attempt was made to test any hypotheses relating to differences in views on safety culture arising from function or rank. However, consideration was given to the distribution of the themes that were identified, detailed in Table 13 (Chapter 4). This distribution revealed three themes common to all twelve focus groups; *policy & procedures, pressure* and *leadership & safety ownership*. The themes of *individual & collective responsibility* and *training & experience* were only present in seven and six groups respectively. Interestingly, there were no themes which were unique to either the aircrew or engineering groups, or from those only containing junior personnel. When considering the content of each theme, there were few unique contrasts in the ways in which different groups of personnel discussed them, indicating fairly consistent views regarding most of the themes identified in Study 1.

The one exception to this, which was tentatively held to indicate a cultural difference, related to a sub-theme of *communication*, that of 'just culture'. This concept was interpreted as referring to personnel being encouraged and supported to provide safety related information in a context where acceptable and unacceptable behaviour was made clear (in line with both Reason, 1998 and The Nimrod Review, Ministry of Defence, 2009). Findings showed that aircrew generally believed that the concept was well accepted and enacted within their function. However, doubts were raised about whether a just culture was enacted amongst the engineer function. It was of interest to note that these views were consistently expressed by aircrew participants during the focus groups, whereas perceptions voiced by engineers were more variable (Study 1). Some senior engineering personnel suggested that junior engineers were happy to report issues, while others acknowledged that this demographic was not as likely to report errors easily or with confidence. Interestingly, the groups of junior engineers (Study 1, groups 9-12) described, at length, barriers to reporting and how having (what they described as) good managers made them more likely to report errors. However, few junior personnel specifically openly raised concerns over the lack of adherence to the principles of a just culture by their management.

If, indeed, there was a difference in the way aircrew and engineers dealt with the consequences of errors, this has the potential to have an impact on organisational learning as there is a foreseeable potential for under-reporting of incidents or near misses. As Study 1 was exploratory, this insight was acknowledged to be preliminary, but some suggestions as to why these different views may exist is offered here for discussion.

The first of these suggestions related to the ways in which work was undertaken by each function. Aircrew inherently worked as part of a crew, typically containing two or three team members who undertook flight duties together. Many of the aircrew tasks required checking and cross-checking by multiple crew members. During these checks, errors might be identified by any of the crew members, and it is in the interests of immediate safety that these are highlighted and addressed. By comparison, a high proportion of the engineering tasks involved maintenance, these tasks were undertaken by one or two personnel and then checked and counter-signed by supervisors on completion. It is possible that there was less scope to check that every aspect of the procedures had been followed (as it is the end result, rather than the process that is verified), thus it may be more likely that maintenance errors may remain undetected.

Furthermore, although engineering may be inherently procedural, diagnosing and fixing engineering issues may not always be possible by simply adhering to set procedures (e.g. fault finding), and so errors may be more 'hidden' in engineering activities. The presence of aircrew errors may be more immediately obvious and hazardous, whereas errors made by engineers may not be realised until some time has elapsed. It must be stated, however, that at no point during the research was it suggested that engineers may knowingly put colleagues in danger. In addition, there is a long tradition of teaching crew resource management (CRM) to aircrew (such a pilots and cabin crew in civilian organisations) which aims to improve communication and team work between pilots and crew. The use of CRM amongst engineers is less prevalent, although an equivalent to CRM for engineers, known as maintenance resource management does exist (Siddiqui, Iqbal & Manarvi, 2012).

Alternatively, different views on just culture may have arisen as a product of the management structure of the different functions. The engineering function has a more traditional hierarchical structure, with a large range of ranks. In contrast, aircrew have a much 'flatter' hierarchical structure, and most of the cadre are of officer rank. Therefore, the hierarchical gradient between ranks is likely to be steeper within the engineering than aircrew functions. The flatter hierarchy gradient within the aircrew function may arguably be conducive to aircrew feeling that they would be treated more fairly by those considered to be colleagues, than engineers might when being judged by their superiors. Further exploration and systematic identification of these potential differences, and the reasons underlying them, were identified as avenues for future research. Recommendations for ways in which this could be achieved are contained within Section 8.4.2.

It should be noted that there are some limitations in the method used in Study 1 which caveat this potential sub-cultural difference. Firstly, the focus groups were split by function (aircrew and engineers) due to the way in which personnel were recruited and assumptions made about the benefits of open conversation if separated by naturally occurring boundaries. There was therefore no opportunity to engage with mixed groups of aircrew and engineers, which might have drawn out contrasts between the functions. There is, however, some supporting quantitative evidence from Study 4 that views on *management commitment & organisational learning* varied between aircrew and engineers; this scale contained items designed to tap perceptions of a just culture.

Safety sub-cultures have previously been identified by Gill and Shergill (2004) who reported differences in perceptions between maintenance engineers and air traffic controllers regarding whether rules should be rigidly followed or be flexible. Similarly, Patankar (2003) reported differences between flight operations personnel and maintenance personnel on rating scales of *pride in company*, *safety opinions* and *supervisor trust*, which he suggested showed evidence of sub-cultural views. McDonald et al. (2000) reported evidence of a professional sub-culture amongst aircraft technicians in which similar views within the aircraft technician function were reported across different companies. In contrast, only a minority of authors have argued that aviation culture is likely to be purely homogenous (Hopkins, 2010).

If the current research was conducted on aircrew and engineers from another comparable military aviation organisation (such as the RAF) and similar findings were reported, this may then be taken as evidence to support a professional subculture (as shown by Rollenhagen et al., 2013 in nuclear power plants). No qualitative studies on safety culture within aviation could be identified in Chapter 2, and this therefore represents an area which requires more attention in future.

The relatively homogenous nature of the views on safety gathered during the focus groups may have arisen from the similarity of flight safety specific training given to all personnel and the almost universal acknowledgement of the high hazard nature of military aviation within the FAA. In addition, while safety culture was the specific focus of this research, this was situated within a wider military culture which could reasonably be expected to have a strong influence on the individual's world views. However, methodologically, the quantitative phases of the research (Studies 3 and 4) were more suited toward systematically exploring potential differences in views than was the qualitative research phase; the quantitative studies set out to characterise safety climate, and explore differences in demographic profiles, and thus were more amenable to looking at differences between groups.

Quantitative findings

An *a prior* hypothesis for Study 4 was that differences on the safety climate scales might be found in relation to two demographic profiles; function (aircrew/engineers) and rank (junior/senior). These hypotheses were based on findings from Study 2 and a number of published studies in the area (Dixon, 2012; Falconer, 2006a; Gill & Shergill, 2004; Patankar, 2003). Figure 7***Figure*** graphically shows mean normalised ratings for each of the proto-sales on the safety climate tool developed in Chapters 6 and 7. Results are shown for both junior and senior engineers and aircrew, with the presence of significant differences indicated. It should be noted that the purpose behind this was to determine whether the scales had the capacity to discriminate between different groups, and thus the set of contrasts explored in this research was indicative rather than exhaustive.

Aircrew safety climate ratings were more positive than ratings for engineering personnel across all five safety climate dimensions (Figure 7) while the differences between senior and junior personnel (when separated by function) showed less definitive results. This was interpreted not as reflecting fundamentally different perspectives on safety i.e. safety culture, but rather perhaps indicating that different shared experiences might affect perceptions of safety climate. Some possible reasons and implications of these differences are discussed in more depth in the following section.

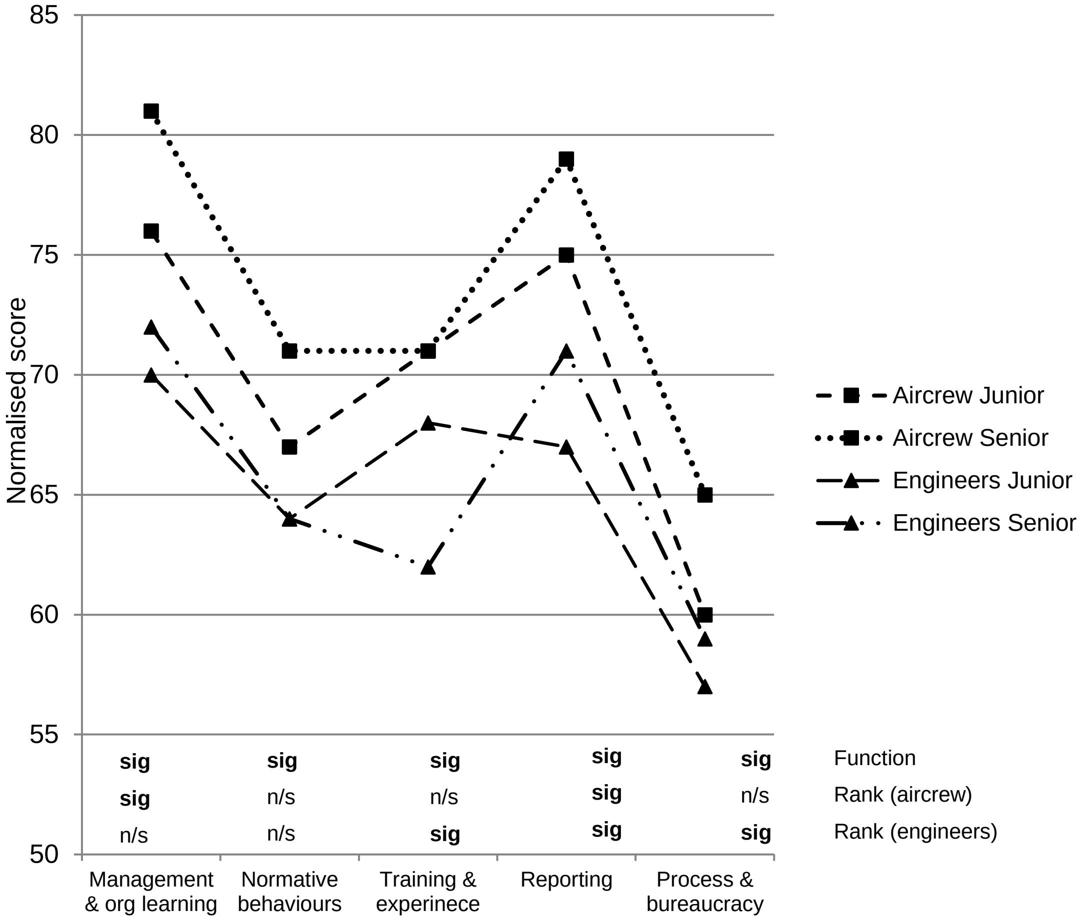

Figure 7. Normalised results (to allow comparison between sub-scales, ratings are expressed here as a percentage of total summated rating) for safety climate scales by function (aircrew and engineers) and rank (junior and senior), showing significant (sig) and non-significant (n/s) differences ($p<0.05$).

<u>Differences by Function: Aircrew and Engineers</u>

Figure 7 showed that there were significant differences between aircrew and engineers on all five of the proto-scales, with aircrew scoring more positively ($p< 0.05$) than engineers in all cases. This would suggest that aircrew considered their management to be more receptive to safety concerns, more supportive of genuine errors and more likely to recognise good safety behaviour than engineers might consider their management to be. Engineers, in contrast, perceived more short-cut taking and increased distraction, as well as less positive views of reporting than aircrew. However, it is important to note that mean ratings across all proto-scales were generally positive; although engineer's ratings of safety climate were significantly lower than those of aircrew, in absolute terms they still reflected positive ratings of safety climate.

The organisational structure of these two functional groups may be relevant to interpreting the findings from the research reported here. Aircrew tend to form a higher proportion of senior management than do engineering personnel, with a greater proportion of senior and junior officers amongst aircrew. In contrast, there are a high proportion of junior rating engineers on each squadron, relative to senior rating engineers or engineering officers. Other researchers have noted that senior staff may provide responses that are self-serving (Biggs et al., 2013; Grote & Kunzler, 2000), and perhaps for this reason often display the most positive safety climate responses when compared with junior staff (Alhemood et al., 2004; Fung et al., 2005; Harvey et al., 2002; Prussia et al., 2004).

The potential implications of these findings to the FAA are two-fold. Firstly, if junior employees consistently have less positive perceptions of the safety climate, it is important to consider reasons why this might be the case. It could be that these personnel are at the most risk of experiencing the tension between safety and operational demands; if so this may be the demographic most likely to take short cuts or compromise safety in the presence of competing demands. The second implication is a methodological one; if the FAA continues to survey its personnel for views on safety climate, it is important to ensure a stratified sample that would encompass both senior and junior personnel, aircrew and engineers, to gain a balanced view of the state of safety climate within the FAA.

The nature of the work undertaken by the different functional groups is also likely to be relevant when interpreting the research findings. While it is true that both aircrew and engineers work to an array of standard operating procedures, pressure from different sources may affect their ability to comply with these procedures. Study 1 (Chapter 4) suggested that engineers, specifically, got frustrated with not being able to access the correct spares or tools to undertake tasks, which in turn may have led to 'work-arounds' or short cuts being taken to allow the work to continue. It is considered possible that there was less flexibility for aircrew to be able to deviate from normal procedures, or indeed take a short cut in their work.

The presence of differences across professional boundaries were consistent with findings in the wider aviation literature (Dixon, 2012; Gill & Shergill, 2004; Patankar, 2003). However, the direction of these differences varied; the current findings were consistent with Dixon's (2012) RAF sample (where aircrew had more positive perceptions of safety climate than did engineers), while both Gill and Shergill (2004) and Patankar (2003), reported more positive views amongst maintenance engineers than flight crew in civilian populations. Gao et al. (2015) observed a number of differences between aviation employees in various functions (pilots, cabin crew, engineers, ground operators) in relation to dissatisfaction with a lack of feedback from safety reports. These authors suggested that sub-climates might be attributed to the distinctive natures of the occupations, different management and policies. Falconer (2006a), reported that ADF pilots considered deviations to procedures to be more unsafe than did ADF engineers.

Differences by Rank: Junior and Senior Personnel

A comparison of safety climate ratings by rank of employee using a combined aircrew and engineer sample was precluded due to the previously discussed differences between aircrew and engineer functions which would likely confound any exploration of ranks between these groups. Furthermore, the large difference in sample size (259 junior engineers and only 96 senior aircrew) between these groups precluded direct comparison. Therefore, comparisons of rank were only made between junior and senior personnel, within each of the functions. As Figure 7 showed, the differences by rank were not as straightforward as those observed by function. In general, however, where differences were found, they tended to reveal senior personnel having more positive perceptions than junior personnel. This was the case for *management and organisational learning* (aircrew only) and *process/bureaucracy* (engineers only).

However, differences between junior and senior ranks of both aircrew and engineers would suggest that perceptions of *reporting* may be particularly prone to differ by rank. Arguably, senior personnel might be more likely to be those investigating or dealing with incidents, while junior personnel were perhaps the least likely to have anything to do with this, unless they were being investigated. This had potential implications for the FAA, as many of the junior personnel were likely to be on the front-line/shop floor where the detection and rectification of errors may be particularly important to ensuring safety. A difference between what senior personnel believe to be happening regarding reporting (i.e. people do report) and reality (i.e. junior personnel know it is important but are not willing to report) might lead to a false sense of security on the part of more senior personnel if reporting rates are low.

However, a key finding that did not fit the pattern of more positive responses amongst senior personnel was observed on the training/experience sub-scale. Here, senior engineers showed the least positive ratings of all groups. This may suggest that these senior engineers had greater reservations about the levels of training and experience amongst colleagues than did other demographics. This might either reflect a greater degree of insight into training/experience shortfalls at more senior engineering management levels, or an actual shortfall in trained or experienced personnel. This could highlight an important area for the FAA to consider for further investigation, as this may need to inform recruitment and training for this cadre.

The findings of Studies 2 and 4 corroborated with each other, with a higher level of agreement observed within sub-populations (separate groups of aircrew and engineers) than within a mixed function group. However, it was notable that this did not seem to be the case for the sample of junior engineers in either study; this group showed particularly low levels of agreement when compared to either senior engineers or aircrew. Speculatively, it seems possible that this lack of agreement amongst junior engineers might reflect a lack of shared time together to create a common view on safety. Alternatively, given the suggested importance of supervisors on safety behaviour, this might reflect the influence of different supervisors on junior engineers, thus creating divergent views on what the safety climate was perceived to be in various units.

Numerous studies have shown that people of different rank/grade (Adamshick, 2007; Desai et al., 2006; Dixon, 2012; Falconer, 2006a) or management level (Alhemood et al., 2004; Harvey et al., 2002; Fung et al., 2005; Pidgeon, 1998; Prussia et al., 2004) varied in their ratings of safety climate. Often a high proportion of the items within safety climate tools relate to aspects of management responsibility, thus this could indicate self-serving/attribution bias on the part of senior personnel/management (as was evidenced by Grote & Kunzler, 2000). Alternatively, these differences could reflect differences in conceptualisations of safety at a variety of ranks/grades (Clarke, 1999) or alternatively reflect a greater insight into the range of safety initiatives throughout the organisation at more senior levels.

Summary

In summary, findings from this research indicated modest evidence of sub-cultural differences. In contrast, ratings of safety climate were shown to vary by both function and rank. Thus, structural and socio-technical aspects of the work environment may have affected how military aviation personnel experienced safety on a day-to-day-basis. However, there was limited evidence to suggest that this necessarily extended as far as reflecting different underpinning beliefs about safety between groups. The importance of the insight gained through this research lay in a better understanding of the impact of context on views on safety, and potentially therefore safety behaviour, of employees. These implications were, however, limited by the fact that there was no subsequent qualitative phase after Study 4; this might have enhanced the findings further by allowing the researcher to investigate in depth potential reasons behind these observed differences in safety climate perceptions. This would have strengthened the findings, and was captured as a recommendation for future research detailed in Section 8.4.2.

8.2 Practical Contributions to Knowledge and Practice

While Section 8.1 addressed the first research aim of this thesis, the following section detailed how the findings from the four empirical studies contributed to the second aim; an increased understanding of factors that may influence organisational learning through identification and application of leading indicators to identify priorities for improvement. The following discussion detailed how the findings from this applied research made practical contributions to knowledge and practice, particularly in relation to considerations for the FAA for practical measures for improvement.

8.2.1 Policy and Procedures

Taken collectively, the results of this research indicated that military naval aviation employees understood and accepted their own role in safety, including the importance of complying with policy/procedures and error/incident reporting. However, barriers to compliance were also identified in Study 1, some of which were then corroborated through Study 3, and these barriers were interpreted as representing practical areas that require addressing. One of these barriers included claims of a large volume of disparate policy and procedures that were constantly changing, inconsistent or inadequate; raising questions of practicability and workability. Study 3 identified *process/bureaucracy* as a safety climate component in its own right. This component displayed the lowest (most negative) safety climate ratings in Study 4, which might have suggested that while perceptions of the safety climate tended toward being positive, there were concerns with the perceived bureaucracy behind reporting and process/procedures.

Given that most tasks within the FAA were, to a greater or lesser degree, defined through policy and procedures, the safety system must inherently assume that these are being adhered to. Organisational barriers (e.g. poor procedures, poor responsiveness to required changes) appeared influential on whether these assumptions in the studies were enacted in employee behaviour. All the barriers identified by personnel have potential negative effects on safety behaviour, as they can result in the adoption of norms or informal ways of working due to the difficulties and penalties (whether actual or perceived) associated with compliance. Thus, it was important for the FAA to be aware of these barriers, in order to hope to address them. By as far as practicable removing barriers/disincentives to compliance, the FAA may in turn reduce the burden of effort on frontline personnel, therefore making safe choices the easy, efficient and productive choice (Battmann & Klumb, 1993).

Suggested practical measures that the FAA could take to address some of the identified barriers included (i) a review of policy/procedures to consolidate disparate information and (ii) better signposting to relevant policy and procedures, both of which could assist employees with identification of those pertinent to their activities. Ensuring that procedures can be performed as documented and within the prescribed timescales could better be achieved through engaging the experience of frontline individuals (Drury & Johnson, 2013; Hale & Borys, 2013; Lamvik et al., 2009) rather than relying on policy/procedure architects who have little recent experience of frontline activities. The importance of these findings for the FAA lay in ensuring that adequate procedures are in place to guide work, but balancing this with the importance of ensuring additional procedures are not the default action to tackle issues that might more appropriately be addressed through other means (such as organisational or structural issues).

8.2.2 Performance Pressure

Through the empirical studies a number of sources of performance pressure were identified which presented as having the potential to negatively influence safety behaviour and risk taking. The practical contributions of this to the FAA lay in the identification of key aspects of the organisational context which may influence safety behaviour, a relationship which has been shown to exist in other sectors (McLain & Jarrell, 2007). A trade-off between operational objectives and safety objectives is widely acknowledged within the safety culture/climate literature (Christian et al., 2009; Mearns et al., 2004; Nordlof et al., 2015; Weyman & Clarke, 2003).

Study 1 identified *pressure* as key to influencing safety; here personnel identified discrepancies in the balance between resources (human, time and equipment) and expected output. Safety requires a significant reliance on resources and insights from goal conflict research has suggested that this kind of incompatibility was likely to lead to workers prioritising some goals at the expense of others (McLain & Jarrell, 2007). Findings from Study 2 indicated that personnel had concerns with the priority afforded to safety, and there was strong agreement that a lack of *human resources* was particularly common within this military naval aviation context.

Study 3 partially supported these findings, with *human resources* being identified as an important component, however this was then not retained in the final safety climate model (Study 4). As pressure has been cited as leading workers to take shortcuts (Mitropoulos & Cupido, 2009; O'Dea et al., 2010), it suggested to be important that the FAA further investigate these perceptions of resource pressures in order to identify what impacts this might have on employee safety behaviour. By identifying specific resource shortfalls, or adjusting output accordingly, it is proposed that this may go some way to supporting, rather than dis-incentivising, safe behaviour. Furthermore, further research is required to determine possible reasons for, and implications of, a lack of personnel resource, as this would help to guide prioritisation and target improvements (see Section 8.4.2 for further details on proposed ways in which this could be achieved).

8.2.3 Influence of Leadership and Peer/Colleagues on Safety

Both leadership and normative behaviours (i.e. informal behaviours observed in others) appeared to be strong influencing factors on safety and risk taking within this population, accounting for equal amounts of explained variance within the quantitative principle component model (derived in Study 3). From a practical perspective, this might suggest that a dual focus is required. Firstly, the importance of ensuring high quality relationships between supervisors and employees appeared to be key, with Study 1 demonstrating how safety behaviours (both positive and negative) can be passed down from more to less experienced individuals. However, high levels of camaraderie potentially meant that conforming with group behaviours might also be integral to maintaining the high cohesion that was indicative of this military population (Study 1). Thus, assuring means by which to enhance coherence between the formal and informal aspects of work should be considered as an important practical aspect for the FAA to address. This might indicate that the role played by managers in setting organisational priorities should be carefully considered. If managers are explicitly or implicitly influencing frontline individuals to work less safely in the face of resource constraints, this may not necessarily reflect the overall priority of safety as directed by senior management.

8.2.4 Development of Safety Climate Measures for Use by the FAA

Practical contributions arising from this research were the foundation work for the development of a bespoke FAA safety climate measure (Studies 3 and 4), and exploration of ranking methods as a means of gaining employee perspectives on priorities for safety improvement (Study 2). With regard to the safety climate tool, further development is required (detailed in Section 8.4.2), however it showed encouraging psychometric robustness, and allowed production of different demographic profiles, indicating that the scales possessed the capacity to discriminate between different groups with the potential to hold different views on safety climate. Study 2 showed that three ranking methods could be used to consistently indicate safety priorities as ranked by frontline personnel. In particular, findings from the method of paired comparisons allowed a nuanced exploration of stand out dimensions of safety that could be used to guide allocation of FAA resources toward safety improvements.

Chapter 2 identified several criticisms of three existing safety climate measures used by military organisations. Firstly, a lack of psychometric development (in the case of the measure utilised in the ADF) and secondly the instability of factor structure of the CSAS and MCAS and lack of replication of the original proposed factors. All three of these measures were developed in a top-down manner, with components being specified in an *a priori* fashion, yet none of the hypothesised factor structures were statistically supported. The safety climate measure developed in the current study is held to represent an advance over existing military safety climate measures through adopting an exploratory, bottom up approach to measure development (Study 1), producing a measure which showed acceptable psychometric properties, using both exploratory and confirmatory statistical techniques (Studies 3 and 4).

The findings from Study 4 gave an indication of how the safety climate measure might be used to highlight weaknesses in safety policy and practices within the FAA and direct where further investigation into the requirements for improvements could be targeted (in line with practices recommended by Huang et al., 2013 & Kines et al., 2011). However, this measure should not be used in isolation, but should be followed by a further data gathering phase which could focus on investigating the weaknesses highlighted by the safety climate measure. This could be combined with the use of a ranking procedure (such as explored in Study 2) and further through conducting focus groups or workshops (as used by Mearns et al., 2013) to generate rich qualitative data to complement the quantitative findings from the safety climate measure and discover reasons underlying the quantitative results.

Summary

It must be noted that to address all the concerns detailed above, considerable resource would be required and therefore prioritisation will likely depend strongly on the costs associated with these issues. For example, although *human resources (*personnel*)* was shown to be a shared concern (a common thread in Studies 2 and 3) for employees, the organisation may find addressing issues of communication of safety priority or competency/experience (identified in Study 2) more manageable and therefore choose to allocate resources to these areas.

Each of the empirical studies highlighted potential areas of concern that could be addressed by the organisation. As the research did not include outcome measures, it has not been shown that amelioration of these concerns would necessarily lead to improvements in safety performance. However, the wider body of literature has shown a relationship between employee safety behaviours (safety participation, compliance and motivation) and safety climate (Christian et al., 2009; Clarke, 2006; Cooper & Phillips, 2004; Johnson, 2007; Zohar & Luria, 2005). Thus, it would appear reasonable to assume that improvements to the factors that influence safety and risk decision making (Studies 1 & 2) and aspects of safety climate (Studies 3 & 4) would be likely to support positive employee safety behaviour. The findings from this research should also be interpreted considering other organisational safety metrics already in existence, such as accidents and incidents and safety audit findings; measures of safety climate can only ever provide one view, and should be interpreted carefully. However, the importance of this is that it allows the organisation to gather employee views which may otherwise not be captured through existing safety performance metrics.

8.3 Theoretical Contributions to Knowledge and Practice

8.3.1 Safety Culture and Climate

Given the maturity of work in the area of safety culture and climate, discovery of new constructs was considered improbable, however there was still considerable scope to enhance understanding and practice in relation to safety culture and climate in the military naval aviation context, including how the identified constructs manifested and played out in a given context such as the FAA. The research reported here used a mix of methods to provide insight into constructs which were relevant to this population and context, to consider why this might have been, and how they might have manifested in the workplace. While reflecting alignment with more recent civilian studies, this approach has not previously been used within a military aviation context.

This approach aimed to address a number of previously cited limitations of safety culture/climate studies, that in employing top-down approaches to determining salient safety culture/climate dimensions/constructs were at risk of producing item batteries essentially based on the best guesses of researchers (Cox & Flin, 1998; Weyman et al., 2006), thus embodying the potential to ignore/overlook/underplay important contextual dependent variables (Reiman & Rollenhagen, 2011). By allowing employee experiences to guide insight into the most salient influences on safety, the research aimed to combat concerns expressed by Guldenmund (2010a) that limiting the scope of inquiry to only common or core themes may result in the bounded, circular rationality that the components of safety climate/culture are measured as merely what researchers imagine them to be.

The research sought to characterise core influences on workplace safety culture, which was achieved through Study 1, and developed into a safety climate measure in Studies 3 and 4. Study 1 corroborated findings from the literature in identifying a set of themes that were interpretable in light of published findings, but with a structure and relative salience which was considered specific to this study, when compared to other factor structures derived from studies within civilian aviation and other high risk industries.

The assertion that culture could be accessed through using climate surveys is partially supported by the current findings, as in several cases the themes and components identified in qualitative and quantitative studies showed compatibility across both. However, the ways in which these latent concepts may fit together often did not. Even after a more grounded approach to developing a safety climate questionnaire, this research raised further questions about the relationship of cultural variables (those which are shared across people) and the psychometric development of safety climate questionnaires whose statistical assumptions may preclude items on which there is general agreement. These were outlined further in the following section.

8.3.2 Reflections on Method

Several of the inconsistencies observed through the findings of the empirical studies may be related to the methods used for each. Two of these related to findings of *human resources* and *individual/collective responsibility*, which merit particular discussion. These dimensions/components were identified in the qualitative phase (Study 1); a lack of *human resources* was grouped along with other factors which related to pressures placed on personnel, while *individual responsibility* (i.e. ensuring safe behaviours because people were responsible for their own and their colleague's safety) was identified as a separate theme.

In Study 3 the issue of pressure caused by a lack of *human resources* loaded onto a separate factor as part of the PCA, however this was removed from the final model (Study 4) in order to improve the model fit. In contrast, this pressure was included in

Study 2 where *human resources* ('There are enough people to do the job safely') was consistently ranked that 'least like' what was observed in the workplace. This may indicate that this component had high salience for study personnel, and that removing it during the CFA may mean that an aspect which was particularly important is removed. There may be, therefore, conflicts between the assumptions for PCA and CFA and the concept of shared employee views on safety.

Similarly, *individual/collective responsibility* was identified as a theme in Study 1, however items related to individual responsibility (e.g. 'People I work with think safety is very important', 'People here are clear about what their responsibilities for safety are', 'People here fully understand the risks associated with the work that they are responsible for') were all removed at an early stage from the PCA due to excessively (positively) skewed data. This may suggest two possibilities; the first is that military aviation personnel agreed that these items were so reflective of their organisation that there were few who would disagree. Alternatively, these items could be strongly affected by social desirability bias due to the high profile of safety across the aviation sector.

Further support for this discussion was drawn from Study 2, where the safety dimension *individual responsibility* ('Everyone accepts that flight safety is their responsibility') was consistently ranked to be 'most like' the situation in a unit. The method of paired comparisons showed this to be a stand out item, which indicated high agreement between personnel. However, the assumptions of factor analytic techniques (such as PCA and CFA) required a certain degree of variability in the data, so removal of highly skewed data is a pre-requisite (Field, 2005). However, the question then arose that by doing this whether the process was simply removing the items which were the most reflective of 'cultural' components because they were items on which most people agree.

A similar question had previously been raised by Guldenmund (2007) who suggested that quantitative safety climate/culture research was caught between the theoretical demands of statistics and the theoretical requirements of culture, however this author offered no further thoughts on this challenge. Wider consideration of published literature showed that the use of self-report questionnaires to solicit the perceptions of an external environmental variable, such as climate has been criticised as it requires people to engage in higher order cognitive processes which involve weighting, inference, interpretation and prediction (Podsakoff & Organ, 1986). However, these measures are often not verifiable by other means, and questionnaires remain as the predominant way in which researchers access abstract concepts such as safety culture or climate (Donaldson & Grant-Vallone, 2002). Through use of mixed methods, the current research has sought to address some of these methodological limitations through using insights from different methods to complement the limitations of others.

8.4 Strengths, Limitations and Recommendations for Future Research

8.4.1 Strengths and Limitations

This thesis has contributed to the body of safety culture and climate knowledge by addressing a number of gaps in the literature, and adopted an applied research approach in order to provide practical contributions to the improvement of safety within the FAA. Unlike previous safety culture/climate research in military contexts (such as the US Navy and the Australian Defence Force), the current research was driven initially by respondent experiences, rather than purely by theory or assumptions made by the researcher regarding elements of importance. This aligned this research, conducted in a military context, with contemporary thinking and applied methods used in civilian studies.

The research adopted a mixed method, participatory approach to characterising safety culture and climate within a UK military naval aviation context. This allowed for triangulation and building up of a more comprehensive view than would be obtained using methods from a single approach. The qualitative phase (Study 1) afforded in-depth contextual insights, which were then generalised to a wider population using quantitative means (Studies 3 and 4). In addition, the insights from the qualitative study allowed greater interpretation of the quantitative results than would have been possible otherwise. The mixed methods approach also allowed the thesis to reflect on the similarities and differences in findings from each study, in light of the strengths and limitations of each.

The use of both exploratory (PCA) and confirmatory (CFA) techniques in initial safety climate scale development (Studies 3 and 4) increased confidence in the findings beyond that which would have been afforded through exploratory techniques alone. Good internal reliability for each of the five safety climate proto-scales (Cronbach alpha >0.70) and demonstration of the capacity of each to detect demographic differences went some way toward demonstrating the reliability and discriminant properties of the scales, both of which were positive with regard to future scale development. The relatively large sample of participants (equating to approximately 10% of the target population in the case of the quantitative phases) which represented a mix of functions and ranks in Studies 1, 3 and 4 was held to add credence to the findings of this research.

This research was requested and supported by the study organisation, and a participatory approach involving frontline individuals and flight safety subject matter experts at various stages to inform the research was seen as a core strength. This was an approach advocated by Guldenmund (2010b), who argued that safety culture inquiry should be carried out in close participation with the organisation to improve the quality of the inquiry.

Through using insights from risk ranking research, the exploratory nature of Study 2 provided support for the use of complementary methods to safety climate questionnaires to assist the organisation with eliciting personnel views on priorities for improvement. This widened the potential range of tools available to the FAA for gaining insight into influences on personnel safety although the requirement for further development of these is acknowledged.

Despite these strengths, the research could be criticised on a number of points. Firstly, both the qualitative and qualitative participant samples were drawn predominately from groups of frontline and middle management personnel. It would have been useful to include interviews with more senior managers who may have had offered different perspectives, however the practical difficulty with which to access these individuals for any significant amount of time precluded this.

Secondly, the group approach to qualitative data collection (Study 1), while justified in Chapter 3, may have inhibited some responses by employees, and elicited socially desirable responses, an aspect which is well acknowledged in safety research (Conchie et al., 2013). An ethnographic approach to considering influences on safety culture may have provided more in-depth insight than was afforded by the focus group discussion (Study 1), however the opportunity for this was limited given the operating environment, and non-military status of the researcher.

The use of self-reported safety climate measures has been criticised for being subjective and greater insight and triangulation of findings may have been gained through analysis of, for example, procedural documents and/or other safety communications in addition to the existing empirical approaches detailed in this thesis. However, the security restrictions which are imposed on this material meant that access to these data were limited for the purpose of conducting a higher research degree.

Study 2 was limited by relatively small sample sizes which made consideration of differences between demographic groups to being exploratory. Furthermore, Study 2 did not include a measure to indicate the relative *importance* of each of the safety culture/climate dimensions to participants. Therefore, there was an assumption made that all the nine dimensions were important to some degree, however further work would be required to corroborate this assumption. The assumption that aspects ranked as 'least like my current unit' might indicate priorities for improvement may be criticised. Whilst the published literature (Chapter 2) and Study 1 indicated that the dimensions contained within Study 2 might all have been important in workplaces which valued safety, it was considered important to challenge this assumption in future studies utilising comparative approaches.

With regard to the factor analytic studies, the sample for the CFA (Study 4) was not recruited in the same way as that for the exploratory PCA (Study 3) due to prevailing logistic considerations associated with access to personnel. This was partly due to changes in military personnel contacts with whom the researcher negotiated access to potential participants during the duration of the research (personnel in the RN tend to change jobs/roles every 24 months). This was also partly due to logistical limitations placed on the researcher due to travel/budgetary restraints set by the sponsor organisation (the RN) over the course of the research, which precluded the researcher personally facilitating data collection for Study 4. Furthermore, although the samples were compared by demographic variables, not all participants provided these details, so the possibility exists that there were some systematic differences between the two samples. Attempts were made to ensure the method of delivery was similar (i.e. paper questionnaires) and participants in all empirical studies were given time during the working day to participate.

The scales developed in Study 4 should only be considered proto-scales as they require further internal and external validation, such as test-retest reliability and criterion/outcome validity. The sample size for Studies 3 and 4, while being large, were not sufficient to allow consideration of the development of demographic-specific safety climate scales (e.g. separate scales for aircrew and scales for engineers), thus for scale development these groups were treated homogenously, which could be criticised in light of the demographic differences in safety climate perceptions noted in Study 4.

The generalisability of the findings detailed in this thesis may be limited to a UK military naval aviation population as this was the sector with which the research was conducted. It is unclear how these findings may compare to other UK or non-UK military aviation organisations and although many aspects of safety culture/climate identified here do seem to overlap with civilian research, the way in which they are operationalised may be limited to the current context.

8.4.2 Future Research Priorities

The research reported here was conducted within the scope and limitations of a doctoral research program, and was shaped by the expectations and requirements of the sponsor organisation. In light of questions raised by the findings of the empirical studies, as well as the strengths and limitations of the research discussed above, several areas are suggested for researchers to extend upon in future research.

Findings from Study 1 indicated a potential cultural difference in the way that personnel from different military naval aviation functions (namely aircrew and engineers) perceived the acceptability of reporting errors/ management support/fair treatment of people who inadvertently made errors (just culture). Potential reasons for this were postulated by the researcher and included: differences in the formal management structure of each function, the predominance of aircrew as senior officers on units and the ways of working of each function. Systematic exploration of these potential differences was identified as an area for further research. As there were no mixed function groups included in Study 1, future research could look to replicate the study, but include mixed function groups (containing participants from both aircrew and engineering functions). If this approach were to be taken, difficulties regarding the differences in rank (aircrew tend to be of higher rank than most maintenance engineers) affecting potential responses would need to be considered and managed. Alternatively, undertaking a series of semi-structured interviews (as compared to focus groups) with aircrew and engineering personnel might be appropriate for exploring cultural differences as it might reduce potential peer pressure affecting responses.

Study 2 acknowledged that the choice of discriminant criterion against which personnel ranked different aspects of safety standards in their workplace was likely to have an impact on the rank order of these different aspects. In the case of Study 2 the chosen discriminant criterion was whether the items were ‘most like’ or ‘least like’ the respondents’ units. However, this assumed that respondents might consider each of the items to be as important as each other. To test this assumption, future research could look to repeat Study 2, but ask respondents to rank the items against the criterion of ‘most to least important to positively influence safe behaviour in your unit’. This might provide further insight into those aspects of safety standards in their workplace that are seen to be most important in encouraging safe work practices. A further suggested alternative criterion might be 'most to least in need of prioritisation to improve safety'.

A second limitation of Study 2 which might be addressed through future research was the lack of senior management participants within the sample. It would be of interest to compare and contrast the rankings of senior management personnel with those of frontline and middle management personnel. This could be undertaken by repeating Study 2, but purposively sampling personnel in senior ranks. A further limitation of Study 2 that might be addressed through further research would be the modest sample size (37 participants). Similar findings from a larger sample, potentially utilising only one of the three ranking techniques, would inform whether the findings from Study 2 would be considered generalisable to a wider military naval aviation population in relation to safety priorities.

While the most negatively ranked items in Study 2 (*human resources, priority of safety* and *competency/experience)* were interpreted as those requiring the highest prioritisation for improvement, future research is required to develop a more in-depth understanding of why these items might be the most negatively ranked, and whether military naval aviation personnel do, in fact, consider these to be priorities that require addressing to lead to safety improvements. This could be achieved through a qualitative study to explore the rationale behind personnel's ranking of the different safety dimensions contained within Study 2.

Exploration of safety climate profiles across an array of demographics in Study 4 revealed significant differences in ratings by both function and rank. Aircrew ratings tended to be more positive (i.e. reflecting more positive views of safety climate) than were ratings by engineers. When considered by rank, the general trend was more positive perceptions of safety climate amongst senior personnel, when compared to junior personnel's perceptions. However, an interesting anomaly was that senior engineers showed significantly less positive views on *training & experience* than did junior engineers. Potential reasons for this were judged to include management structure and ways of working, as well as the potential for self-serving responses provided by more senior personnel. However, these differences would be best explored systematically in future research through a further phase of qualitative inquiry to explore reasons behind the differences observed in the quantitative findings.

Although the safety climate measurement tool developed in Studies 3 and 4 showed good reliability in terms of the internal consistency of the scales, further research is needed to demonstrate its stability over time (test-retest reliability). This would require the safety climate measure (shown in Table 49) to be administered to the same group of participants at two timepoints, preferably over a week apart (Oppenheim, 2000). Furthermore, future work is required to consider the criterion-related validity of the safety climate tool. This would require different approaches to address different criterion-related validity types:

- Predictive validation would entail validating the safety climate tool against organisational safety outcomes, although this is acknowledged to be challenging in applied settings (Guldenmund, 2007, 2010a). However, options for achieving this include collecting self-reported accident/incident data (in line with Huang et al., 2013), recorded occupational accidents (such as completed by Zohar, 2000), safety behaviour (in line with Clarke, 2006; Griffin & Neal, 2000), or other organisational safety performance indicators, alongside questionnaire data to determine the degree of association between these variables. If completed longitudinally, future research could explore whether safety climate has any predictive validity with regard to accidents or safety behaviour, or whether accidents/safety behaviour might predict safety climate.
- Convergent validity might be examined through administering another safety climate measurement tool (such as the NOQSAQ 50, Kines et al., 2011) alongside the measurement tool developed in Studies 3 and 4, and determine the correlation between both questionnaires (which, in theory, should be measuring similar constructs).

Insights were only gained from two FAA demographics (aircrew and engineers) and future research also may benefit from considering wider inclusion of other roles within UK military naval aviation, such as air traffic controllers and support personnel. The generalisability of the findings from this research to other UK non-aviation (e.g. British Army, Royal Navy/Royal Marines) or aviation (e.g. Royal Air Force, Army Air Corps) military organisations is unknown. Given the different structures, operational focus and ethos across the different UK Armed Forces groups, it is suggested that the use of a similar phased approach to considering safety culture and climate in other UK military organisations may provide insight into the degree of comparability of findings across military organisations within the UK Armed Forces.

Section 8.2 contained a number of practical recommendations made to the FAA for improvements to various aspects of the safety system within the organisation. Future research should look to design and determine the efficacy of safety-related interventions taken to address some of the concerns raised in this research. This could include pre- and post-intervention measures of both subjective (e.g. using the safety climate tool to look at changes in perception, or employee feedback via workshops/focus groups/interviews) and objective (e.g. observation of safety behaviour, number of reports, number of incidents/injuries) data. A future study would need to identify both an experimental and control group who were exposed to similar level of hazards in which the same outcome measures could be applied.

The current research was cross-sectional, however to facilitate a longitudinal approach, the FAA would benefit from conducting a safety climate survey at regular intervals, e.g. annually, which would allow the tracking of safety climate perceptions over time to determine changes. This method will likely be familiar to most in the organisation, and provides a structured method by which safety interventions could be applied and tracked over time.

8.5 Conclusions

- Findings from Studies 1 and 2 facilitated the articulation of factors that influenced safety and risk decision making which had high relevance for military naval aviation employees.
    - Operating rules and procedures were presented as having strong cultural legitimacy; they were widely viewed by operational personnel as both necessary and appropriate. However, barriers to compliance with these were identified, and practical recommendations for the FAA to consider were suggested to aid in the removal of these barriers.
    - Safety policy was viewed by participants fairly cynically, with accountability and bureaucracy perceived to have increased in recent years. This was said to leave employees feeling personally vulnerable in the event of unintentional violations. Review and consolidation of policy within the FAA was recommended to address these issues.
    - The dominant pressure experienced by participants was an over-arching requirement to deliver operational capability. Provision of resources, including

personnel, were described as key to the ability to work safely. The lack of *human resources* (i.e. personnel) was a shared concern for military naval aviation personnel, as was a lack of focus on the *priority of safety*. Further understanding the implications and impact of inadequate resources on safety was recommended to be a future research requirement for the FAA.

  - Supervisors were cast as key influences on safety, leading by example and teaching behaviour, both in positive and negative aspects (i.e. compliance or short cuts). In contrast, the motivations of senior management were viewed rather cynically. The impact of managers on resource allocation, priority setting and organisational learning were articulated within the findings from this research.
  - There was a strong, overriding sense of organisational commitment amongst personnel; they were proud to belong to the FAA and took pride in its positive safety reputation.

- Five constructs (identified in Studies 3 and 4) were considered to characterise core elements of employee perspectives on influences on safety and risk decision making in the UK military naval aviation context. These were *management commitment and organisational learning*, *normative behaviour*, *training and experience*, *reporting* and *process/bureaucracy.* These components were identified first using a principle components analysis and then a re-specified model was determined to display acceptable model fit using a confirmatory factor analysis.
- Foundation work on measure development aimed at characterising employee perceptions of safety climate has the potential for the basis of a tool that could be used to benchmark perceptions of safety climate and therefore inform organisational learning and intervention strategy. The FAA could use such a safety climate tool, once fully developed, to monitor safety climate longitudinally in comparison to the cross-sectional approach taken in this research.
- When three comparative ranking methods (Q-Sorting, direct ranking and the method of paired comparisons) were used to rank influences on safety (Study 2), results from all three methods reflected a similar rank structure. This use of multiple techniques afforded additional confidence in the results, allowing insight into the headline areas for improvement (*human resources, priority of safety* and *competency/experience*), particularly when the three methods showed significant agreement in output/rank order of dimensions. While the method of paired comparisons was considered the most frustrating method to complete when compared to the other two, it displayed the highest levels of agreement and afforded the most nuanced insight into the relative importance of priorities to each other.

- While there was only modest evidence of sub-cultural differences between different aviation profession groups, perceptions of safety climate did appear to vary by function (aircrew and engineers) and rank of personnel (junior and senior). Aircrew were seen to have statistically more positive views toward safety climate elements than engineers, while junior ranks typically displayed less positive views than did senior personnel.
- The use of multiple methods allowed consideration of the aims of the research from different viewpoints. However, some inconsistencies were found which may have been influenced by the methods utilised. In Study 1, a lack of *human resources* was found to affect views on safety, whilst participants cited high levels of *individual responsibility* for safety. Study 2 supported these findings, with these factors consistently ranked as 'least' and 'most' like the situation observed in respondent's units. However, in Study 3 items related to *human resources* and *individual responsibility* were removed from the PCA and CFA due to a lack of variability in the data. This may indicate that these components, while having high salience for personnel, were incompatible with the assumptions of the PCA and CFA techniques. There may be, therefore, a conflict between the assumptions for statistical techniques such as PCA and CFA and the assumption of shared world views inherent within the concepts of safety culture and climate.
- Given the maturity of work in safety culture and safety climate, discovery of new constructs was considered improbable, however there was still considerable scope to enhance understanding and practice in relation to safety culture and safety climate in the military naval aviation context. There was further uniqueness in the combination and content of constructs from this study, when compared to findings from other aviation/high risk sectors, which were detailed in the integrated discussion of this research (Chapter 8).
- The current research reflected a mix of methods, which used insights grounded in employee experiences to identify influences on safety, thus aligning with contemporary civilian studies. This bottom-up approach had not yet been applied by military safety culture or climate studies.
- In-depth contextual insights were afforded by qualitative methods, while the quantitative methods allowed consideration of the generalisability of the findings and comparisons between groups to be drawn.
- The scales identified in Studies 3 and 4 should only be considered to be proto-scales as they require further reliability analysis (test-retest reliability) as well as validation (predictive and convergent validity).

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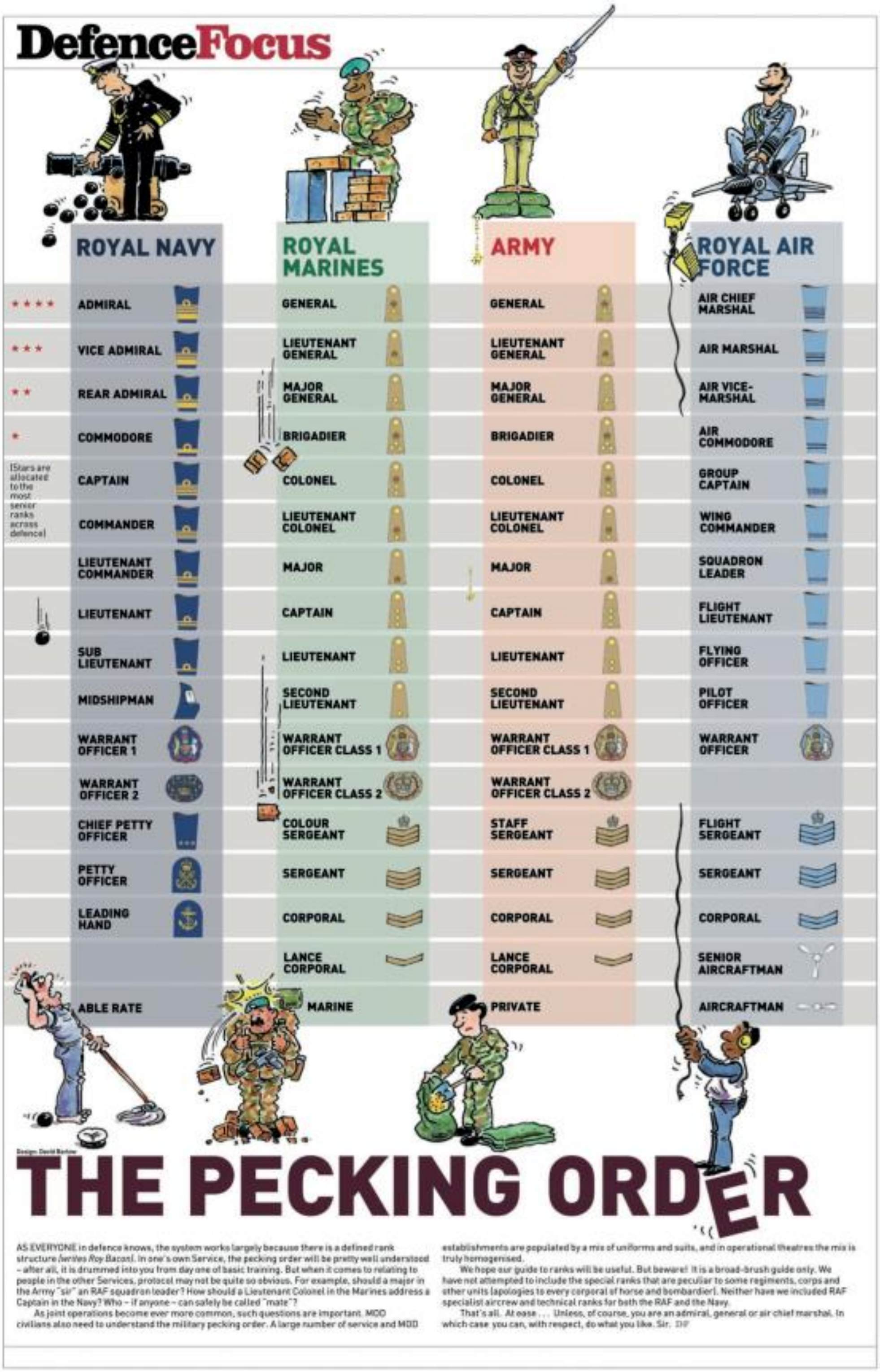
Appendix A-Introduction

NATO rank structure across the UK Armed Forces



DefenceFocus

	ROYAL NAVY	ROYAL MARINES	ARMY	ROYAL AIR FORCE
★★★★	ADMIRAL	GENERAL	GENERAL	AIR CHIEF MARSHAL
★★★	VICE ADMIRAL	LIEUTENANT GENERAL	LIEUTENANT GENERAL	AIR MARSHAL
★★	REAR ADMIRAL	MAJOR GENERAL	MAJOR GENERAL	AIR VICE-MARSHAL
★	COMMODORE	BRIGADIER	BRIGADIER	AIR COMMODORE
[Stars are allocated to the most senior ranks across defence]	CAPTAIN	COLONEL	COLONEL	GROUP CAPTAIN
	COMMANDER	LIEUTENANT COLONEL	LIEUTENANT COLONEL	WING COMMANDER
	LIEUTENANT COMMANDER	MAJOR	MAJOR	SQUADRON LEADER
	LIEUTENANT	CAPTAIN	CAPTAIN	FLIGHT LIEUTENANT
	SUB LIEUTENANT	LIEUTENANT	LIEUTENANT	FLYING OFFICER
	MIDSHIPMAN	SECOND LIEUTENANT	SECOND LIEUTENANT	PILOT OFFICER
	WARRANT OFFICER 1	WARRANT OFFICER CLASS 1	WARRANT OFFICER CLASS 1	WARRANT OFFICER
	WARRANT OFFICER 2	WARRANT OFFICER CLASS 2	WARRANT OFFICER CLASS 2	
	CHIEF PETTY OFFICER	COLOUR SERGEANT	STAFF SERGEANT	FLIGHT SERGEANT
	PETTY OFFICER	SERGEANT	SERGEANT	SERGEANT
	LEADING HAND	CORPORAL	CORPORAL	CORPORAL
		LANCE CORPORAL	LANCE CORPORAL	SENIOR AIRCRAFTMAN
	ABLE RATE	MARINE	PRIVATE	AIRCRAFTMAN

Design: David Barlow

THE PECKING ORDER

AS EVERYONE in defence knows, the system works largely because there is a defined rank structure *(writes Roy Bacon)*. In one's own Service, the pecking order will be pretty well understood – after all, it is drummed into you from day one of basic training. But when it comes to relating to people in the other Services, protocol may not be quite so obvious. For example, should a major in the Army "sir" an RAF squadron leader? How should a Lieutenant Colonel in the Marines address a Captain in the Navy? Who – if anyone – can safely be called "mate"?

As joint operations become ever more common, such questions are important. MOD civilians also need to understand the military pecking order. A large number of service and MOD establishments are populated by a mix of uniforms and suits, and in operational theatres the mix is truly homogenised.

We hope our guide to ranks will be useful. But beware! It is a broad-brush guide only. We have not attempted to include the special ranks that are peculiar to some regiments, corps and other units (apologies to every corporal of horse and bombardier). Neither have we included RAF specialist aircrew and technical ranks for both the RAF and the Navy.

That's all. At ease . . . Unless, of course, you are an admiral, general or air chief marshal. In which case you can, with respect, do what you like. Sir. DF

Appendix B-Study 1

Method

Participant Information Sheet

PARTICIPANT INFORMATION SHEET

Investigating the antecedents to Safety Culture in the Fleet Air Arm.

(MODREC Protocol No: 444/Gen/13)

Invitation to take part

We would like to invite you to participate in this study being undertaken by the Institute of Naval Medicine (INM) in support of the Royal Navy Flight Safety Centre (RNFSC).

Before you decide whether you want to take part, it is important for you to understand why the research is being undertaken and what your participation will involve. Please take time to read the following information carefully.

What is the purpose of the research?

The aim of the research is to explore the attitudes and perceptions of Fleet Air Arm personnel towards safety within the Royal Navy in light of findings from Flight Safety Surveys that have been collected by the RNFSC for a number of years. The aim is also to explore the survey findings in more detail. Additionally the research aims to investigate any aspects of Flight Safety not adequately addressed by the Flight Safety Survey. This will inform the RNFSC with regards to requirements for resources for safety improvements, further elucidate the attitudes of FAA personnel toward safety. The ultimate aim is to support effective safety and risk management to ensure ongoing operational capability.

Who is doing this research?

This study is being undertaken by MOD personnel from the Institute of Naval Medicine (INM) on behalf of the Royal Navy Flight Safety Centre (RNFSC).

Why have I been invited to take part?

You have been specifically invited to participate in this study as you are a member of the Fleet Air Arm.

Do I have to take part?

Participation in the study is voluntary. Any responses will be confidential.

What will I be asked to do?

A verbal brief of the project will occur, during which you will be asked to participate in a focus group, which is a group discussion regarding safety within your unit and organisation. This discussion will take approximately 60 minutes-this time will be allocated within the course and will not affect the length of your course. You will be asked to consent to take part in the study, and the procedures will be explained to you. You will then be asked to participate in discussions regarding a number of safety related topics guided by the Researcher, but the aim is to achieve group discussion-so you are talking with the group, not to the Researcher.

This discussion will be recorded in order to allow for accurate transcripts of the discussion. These recordings will be transcribed, and anything that can identify individuals (names, units, roles) will be removed prior to analysis. Only the research team will have access to the original recordings and all content will be kept securely according to the Data Protection Act (1998). It is important that you know that your discussions are completely confidential and no one in the Chain of Command will see individual responses.

What is the device or procedure that is being tested?

An assessment of the attitudes and perceptions toward Safety Culture of Fleet Air Arm personnel is being undertaken.

What are the benefits of taking part?

The results from this study will inform the Fleet Air Arm on the reasons behind the findings of the Flight Safety Surveys. This will help them to understand where resources to improve safety should be placed. Additionally, other factors affecting FAA personnel's attitudes toward safety will be explored.

What are the possible disadvantages and risks of taking part?

There are no expected disadvantages or risks of taking part.

Can I withdraw from the research and what will happen if I don't want to carry on?

You may withdraw from the study at any time without giving a reason. If you have any concerns that arise from your participation and do not feel comfortable discussing them with the Principle Investigator, the details of the Independent Medical Officer (Psychologist) are included below.

Are there any expenses and payments which I will get?

No

Will my taking part or not taking part affect my career?

You should only participate if you wish to do so; choosing not to take part will not disadvantage you in any way with regards to either your career or on the Flight Safety Course.

Whom do I contact if I have any questions or a complaint?

If you have any questions concerning this study, please do not hesitate to contact the Principal Investigator or Independent Medical Officer (contact details below).

What happens if I suffer any harm?

In the event of you suffering any adverse effects as a consequence of your participation in this study, you will be eligible to apply for compensation under the MOD's 'No Fault Compensation Scheme'.

Will my records be kept confidential?

Records will at all times remain confidential and will be held for a minimum of 100 years in conditions appropriate for the storage of personal information. You have the right of access to your records at any time, and to ask for them to be destroyed.

Who is organising and funding the research?

This study is being funded by the UK MOD.

Who has reviewed the study?

A scientific protocol for this research has been approved by The Ministry of Defence Research Ethics Committee (MODREC).

Further information and contact details.

Contact Details of Principal Investigator:

Ms Anthea Bennett (Higher Scientific Officer)
Environmental Medicine and Science, Institute of Naval Medicine,
Crescent Road, Alverstoke, Hants. PO12 2DL
Telephone: [redacted]; [redacted]
Email: [redacted]

Contact Details of Independent Medical Advisor (Psychologist):

Dr Shaun Kilminster
Telephone: [redacted]
E-mail : [redacted]

Compliance with the Declaration of Helsinki.

This study complies, and at all times will comply, with the Declaration of Helsinki[5] as adopted at the 52nd WMA General Assembly, Edinburgh, October 2000 and with the Additional Protocol to the Convention on Human Rights and Biomedicine, concerning Biomedical Research, (Strasbourg 25.1.2005). Please ask the Principal Investigator if you would like further details of the approval or to see a copy of the full protocol.

[5] World Medical Association (2000) Declaration of Helsinki. Ethical principles for medical research involving human subjects. 52nd World Medical Association General Assembly, Edinburgh, Scotland October 2000.

Informed Consent

CONSENT FORM FOR PARTICIPANTS IN RESEARCH STUDIES

Title of Study: Investigating the antecedents to Safety Culture in the Fleet Air Arm

Ministry of Defence Research Ethics Committee Reference: 444/Gen/13

- The nature, aims and risks of the research have been explained to me. I have read and understood the Participant Information Sheet and understand what is expected of me. All my questions have been answered fully to my satisfaction.

- I understand that if I decide at any time during the research that I no longer wish to participate in this project, I can notify the researchers involved and be withdrawn from it immediately without having to give a reason for my withdrawal. I also understand that I may be withdrawn from it at any time, and that in neither case will this be held against me in subsequent dealings with the Ministry of Defence.

- I understand that the screening process to decide if I am suitable to be selected as a subject may include completing a medical screening questionnaire and/or a physical examination by a medical officer and I consent to this.

- I consent to the processing of my personal information for the purposes of this research study. I understand that such information will be treated as strictly confidential and handled in accordance with the provisions of the Data Protection Act 1998.

- I agree to volunteer as a subject for the study described in the information sheet and I give full consent to my participation in this study.

- This consent is specific to the research described in the Participant Information Sheet attached and shall not be taken to imply my consent to participate in any subsequent experiment or deviation from that detailed here.

- I understand that in the event of my sustaining injury, illness or death as a result of participating as a volunteer in Ministry of Defence research, I or my dependants may enter a claim with the Ministry of Defence for compensation under the provisions of the no-fault compensation scheme, details of which are attached.

Participant's Statement:

I ____

agree that the research project named above has been explained to me to my satisfaction and I agree to take part in the study. I have read both the notes written above and the Participant Information Sheet about the project, and understand what the research study involves.

Signed Date

Witness Name

Signature

Investigator's Statement:

I ____

confirm that I have carefully explained the nature, demands and any foreseeable risks (where applicable) of the proposed research to the Participant.

Signed Date

AUTHORISING SIGNATURES

The information supplied above is to the best of my knowledge and belief accurate. I clearly understand my obligations and the rights of research participants, particularly concerning recruitment of participants and obtaining valid consent.

Signature of Principal Investigator

………………………………………………… Date

Name and contact details of Independent Medical Officer (if appropriate):

Dr Shaun Kilminster
[redacted]

Name and contact details of Principal Investigator:

Institute of Naval Medicine [redacted]
Crescent Rd
Alverstoke
Hants
PO12 2DL

Focus Group Proforma

Introduction and warm up

Moderator to explain:

1. The purpose of the group discussion session, the rationale underlying the research interest in safety culture.
2. Participants will be made aware that they are under no obligation to take part- they may leave the group at any point.
3. Participants will be assured of anonymity and the requirement for all discussions to remain confidential.
4. Participants will be informed that this discussion is *not* an investigation to identify individuals who may be involved in safety-related cases, rather to discuss attitudes towards safety in the Fleet Air Arm. Participants will be informed of the requirement for the researcher to report any actions spoken about that may be deemed criminal. Examples will be given and the agreement between the Investigator and the Royal Navy Flight Safety Centre (RNFSC) will be detailed.

Focus group proforma

- Tell me about safety within the Fleet Air Arm.
  - Has it changed over time, and if so, how?
  - What about safety at your unit-is it different?
  - Is it different working in the FAA now compared to, e.g. 5 years ago?
    - What has changed, what has not changed?
- What are the main barriers to safety within your workplaces?
  - What do you consider to be the main factors that mean you cannot work safely?
  - What are the safety priorities for you?
- What are the main contributors to accidents/incidents?
  - Can you give me an example of an accident you know about and what caused it?
    - Did you see any changes implemented after the accident?
  - Have the causes changed over time?
  - What are the big safety issues where you work?
- How important are safety procedures to the way you work?
- Do people bend/break the rules-can you give any examples?
  - What makes them bend/break rules?
  - What would people worry about if they chose not to follow the rules?
  - Everybody takes risks of some sort in daily life-if people in the FAA take risks, can you think why they might do that?
- Is there anything more you feel I should have asked/you want to discuss with the group?

Moderator to thank group for participation, reiterate requirement for discussions to remain confidential and provide sources of support if required.

Appendix C-Study 2

Method

FAA Flight Safety Q-Sort Items

Table 1.

Royal Navy Fleet Air Arm Flight Safety Q-Sort items.

	Item	Theme*
1	Personnel in my unit understand the concept of Flight Safety	Individual actions/ responsibility
2	Unit level managers take the lead on Flight Safety issues	Management commitment/actions
3	Rules are not bent because of work pressure	Priority of Safety
4	Everyone receives the correct level of Flight Safety training	Safety training
5	Incidents that have flight safety implications are always reported	Communication
6	Everyone accepts that flight safety is their responsibility	Individual actions/ responsibility
7	Individuals are empowered to take action in the interests of flight safety	Individual actions/ responsibility
8	Flight safety risks are considered in the normal planning/briefing cycle	Safety systems
9	The work environment is always conducive to safe operations	Work environment
10	Everyone is fully trained to undertake the tasks that are required of them safely	Safety training
11	In my unit procedures are in place to promote flight safety awareness	Safety systems
12	The impact of change on flight safety is always considered by the organisation	Priority of Safety
13	Flight safety is more important that cost saving measures	Priority of Safety
14	Flight safety is an integral part of routine training	Safety training
15	Suggestions to improve flight safety are always followed up	Communication
16	In my unit it is appropriate to question instructions when	Communication

	flight safety is at stake	
17	Individuals are comfortable reporting their own mistakes	Individual actions/ responsibility
18	Flight safety risks are never taken to ensure that a job is completed on time	Priority of Safety
19	All the necessary equipment is provided to allow tasks to be carried out safely	Resourcing
20	The correct numbers of competent personnel with the right levels of experience are available on my unit	Resourcing
21	There is a just culture in my unit	Management commitment/actions

* According to original authors (Zar et al., 2002)

NASA-TLX definitions

Table 2.

The NASA-Task Load Index (TLX) definitions, taken from Hart & Staveland (2006).

Rating scale definitions	
Title	Descriptions
Mental demand	How much mental and perceptual activity was required (e.g. thinking, deciding, calculating, remembering, looking, searching)? Was the task easy, or demanding, simple or complex, exacting or forgiving?
Physical demand	How much physical activity was required (e.g. pushing, pulling, turning, controlling, activating)? Was the task easy or demanding, slow or brisk, slack or strenuous, restful or laborious?
Temporal demand	How much time pressure did you feel due to the rate or pace at which the task elements occurred? Was the pace slow and leisurely or rapid and frantic?
Effort	How hard did you have to work (mentally and physically) to accomplish your level of performance?
Performance	How successful do you think you were in accomplishing the goal of the task? How satisfied were you with your performance in accomplishing this goal?
Frustration level	How insecure, discouraged, irritated, stressed and annoyed versus secure, gratified, content, relaxed and complacent did you feel during the task?

Presentation of the three ranking methods

Table 3.

Latin square design used in Study 2.

Participant	1st administration	2nd administration	3rd administration
1	PC	DR	QS
2	DR	QS	PC
3	QS	PC	DR
4	QS	DR	PC
5	PC	QS	DR
6	DR	PC	QS
7	PC	DR	QS
8	DR	QS	PC
9	QS	PC	DR
10	QS	DR	PC
11	PC	QS	DR
12	DR	PC	QS
13	PC	DR	QS
14	DR	QS	PC
15	QS	PC	DR
16	QS	DR	PC
17	PC	QS	DR
18	DR	PC	QS
19	PC	DR	QS
20	DR	QS	PC
21	QS	PC	DR
22	QS	DR	PC
23	PC	QS	DR
24	DR	PC	QS
25	PC	DR	QS
26	DR	QS	PC
27	QS	PC	DR
28	QS	DR	PC
29	PC	QS	DR
30	DR	PC	QS
31	PC	DR	QS

32	DR	QS	PC
33	QS	PC	DR
34	QS	DR	PC
35	PC	QS	DR
36	DR	PC	QS
37	PC	DR	QS
38	DR	QS	PC
39	QS	PC	DR
40	QS	DR	PC
41	PC	QS	DR
42	DR	PC	QS
43	PC	DR	QS
44	DR	QS	PC
45	QS	PC	DR

Note: PC = method of paired comparison, QS= Q-Sort, DR= direct rank ordering

NASA-TLX Questionnaire

These questions are about the **ranking task** you have just completed. For each of the following scales, please mark a cross in the box which matches your experience of performing the **ranking task**.

For example:

X

Very low Very high

Mental Demand
How mentally demanding was the task?

Very low Very high

Physical Demand
How physically demanding was the task?

Very low Very high

Temporal Demand
How hurried or rushed was the pace of the task?

Very low Very high

Performance
How successful were you in accomplishing what you were asked to do?

Perfect Failure

Effort
How hard did you have to work to accomplish your level of performance?

Very low Very high

Frustration
How insecure, discouraged, irritated, stressed and annoyed were you?

Very low Very high

Do you have any additional comments about the ranking task?

Participant information sheet

Ethical approval code 17-132

Exploring and characterising safety culture and risk decision making in the military

Before you decide to take part in this study, it is important for you to understand why the research is being done and what it would involve. Please take time to read the following information carefully and discuss it with friends, colleagues or your line manager. Ask us if there is anything that is not clear or if you would like more information. Take time to decide whether or not you wish to take part.

Background

This study is being undertaken by the Institute of Naval Medicine (INM) and part of this work will form the basis of a Doctoral thesis undertaken by the Chief Investigator at the University of Bath. This is a study to look at the Flight Safety Q-Sort (currently completed by people on the Air 302 course) and compare it to some different methods to determine which method might be best for the Flight Safety Centre to use as information on personnel's views on safety and safety culture within their unit. This will help to inform the RNFSC with regards to areas of concern or good safety culture and support the Safety Management System of the Fleet Air Arm.

Procedures

You have been invited to participate because you are employed by the Royal Navy, within the Fleet Air Arm. To participate you should be over the age of 18. However, participation in the study is entirely voluntary. It is up to you to decide whether or not to do this. If you do decide to take part, we would ask you to sign a consent form and give you a copy of this information sheet and the consent form to keep. If you decide to take part you are still free to withdraw from the study at any time. If you decide not to take part, or to withdraw, you do not have to give a reason and there will be no negative impact on you, or your career.

If you take part, we would ask you to complete three activities on one day, at the start and end of the work day and at lunchtime. These will be completed in work time, and you will not be required to use your own free time. These are paper based activities and will ask you to rank various items, either as a whole or as pairs of items. The instructions for each will be provided for you, and you can ask questions if you are unsure. In total this will take approximately 1 h 15 mins, broken down into the three times (beginning, middle and end of day). Upon completion of the final activity (at the end of the work day) there will be a short de-brief session where we will tell you about the three methods and what we could expect to learn from each. You will have the opportunity to ask any questions.

Your data

All data collected in this study will be anonymised. There is no record that links the data collected from you with personal data from which you could be identified (i.e. the signed consent form). You may withdraw from the study at any time without giving a reason, the details of the Chief Investigator are included for contact if this is the case. Your data will be withdrawn from the study at your request and there will be no impact on your career.

If you have any questions at any time about the study, please do not hesitate to contact Anthea Ashford on 02392768044, A.I.Bennett@bath.ac.uk.

If you have any concerns related to your participation in this study, please direct them to the Psychology Research Ethics Committee, via Nathalia Gjersoe (n.gjersoe@bath.ac.uk) 0117 9287841

Informed consent

CONSENT FORM
Exploring and characterising safety culture and risk decision making in the military
Confidential

Please answer the following questions to the best of your knowledge

DO YOU CONFIRM THAT YOU:

- Are employed by the Fleet Air Arm
  - ☐
  - ☐
- Are over 18 years of age
  - ☐
  - ☐

HAVE YOU:

- been given information explaining about the study?
  - ☐
  - ☐
- had an opportunity to ask questions and discuss this study?
  - ☐
  - ☐
- received satisfactory answers to all questions you asked?
  - ☐
  - ☐
- received enough information about the study for you to make a decision about your participation?
  - ☐
  - ☐

DO YOU UNDERSTAND:

that you are free to withdraw from the study and free to withdraw your data prior to publication

- at any time?
  - ☐
  - ☐
- without having to give a reason for withdrawing?
  - ☐
  - ☐

I hereby fully and freely consent to my participation in this study

I understand the nature and purpose of the procedures involved in this study. These have been communicated to me on the information sheet accompanying this form.

I understand and acknowledge that the investigation is designed to promote scientific knowledge and that the University of Bath will use the data I provide for no purpose other than research.

I understand the data I provide will be kept **confidential**. My name or other identifying information will not be disclosed in any presentation or publication of the research.
I understand that the University of Bath may use the data collected for this project in a future research project but that the conditions on this form under which I have provided the data will still apply.

Participant's signature: ______________________________________ Date: ________________

Name in BLOCK Letters: ______________________________________

Final consent

Having participated in this study

I agree to the University of Bath keeping and processing the data I have provided during the course of this study. I understand that these data will be used only for the purpose(s) set out in the information sheet, and my consent is conditional upon the University complying with its duties and obligations under the Data Protection Act.

Participant's signature: ______________________________________ Date: ________________

Name in BLOCK Letters: ______________________________________

If you have any concerns related to your participation in this study please direct them to the Department of Psychology Research Ethics Committee, via Nathalia Gjersoe, Psychology Research Ethics Officer (Tel: 01225 38 3251 email: N.Gjersoe@bath.ac.uk).

Results

Table 4.

Friedman's test statistics between individual rank order position of the safety climate dimensions across the three ranking methods.

Dimension	Method	Mean rank	*Chi*^{2}	Significance (*p*)
Individual actions	Direct Ranking	2.22		
	Q-Sort	1.80	6.514	0.039
	Paired Comparison	1.99		
Management commitment	Direct Ranking	2.27		
	Q-Sort	1.53	14.8	0.001
	Paired Comparison	2.20		
Priority of safety	Direct Ranking	2.42		
	Q-Sort	1.22	39.48	0.001
	Paired Comparison	2.36		
Safety training	Direct Ranking	2.30		
	Q-Sort	1.55	15.54	0.001
	Paired Comparison	2.15		
Communication	Direct Ranking	2.42		
	Q-Sort	1.39	25.46	0.001
	Paired Comparison	2.19		
Safety system	Direct Ranking	2.08		
	Q-Sort	1.54	15.08	0.01
	Paired Comparison	2.38		
Working environment	Direct Ranking	2.53		
	Q-Sort	1.41	28.77	0.001
	Paired Comparison	2.07		
Manpower	Direct Ranking	2.51		
	Q-Sort	1.15	48.69	0.001
	Paired Comparison	2.34		
Competency/experience	Direct Ranking	2.41		
	Q-Sort	1.18	42.93	0.001
	Paired Comparison	2.24		

Table 5.

*Wilcoxon's statistical test results for the rank order of dimensions (***** indicates significant difference).*

Dimension	QS -DR Z (sig)	PC-DR	PC-QS
Individual actions	-2.375 (0.018)	-1.561 (0.119)	-1.509 (0.131)
Management commitment	-3.695 (0.001) *****	-0.932 (0.351)	-3.439 (0.001) *****
Priority of safety	-4.925 (0.001) *****	-0.862 (0.389)	-4.693 (0.001) *****
Safety training	-3.429 (0.001) *****	-0.996 (0.319)	-2.959 (0.003) *****
Communication	-4.350 (0.0001) *****	-1.127 (0.260)	-3.861 (0.0001) *****
Safety system	-2.904 (0.004) *****	-1.112 (0.266)	-3.990 (0.0001) *****
Working environment	-4.451 (0.0001) *****	-2969 (0.003) *****	-3.807 (0.001) *****
Manpower	-5.159 (0.001) *****	-0.389 (0.697)	-5.139 (0.0001) *****
Competency/experience	-4.668 (0.0001) *****	-4.464 (0.643)	-5.064 (0.0001) *****

Where QS = Q-Sort; DR= direct ranking; PC =method of paired comparisons; sig=significance level

Appendix D- Study 3

Method

78 item questionnaire

1 People I work with think safety is very important
2 More people are made available to do a job if needed for safety reasons
3 There is support from line management in safety critical situations
4 Managers here are willing to listen to staff when it comes to the best way to do something
5 The Squadron Management encourages safe working practices
6 If people here saw an unsafe act they would report it
7 Generally, teams work well together in this organisation
8 Taking a shortcut to get work done quickly is seen as acceptable, as long as nothing happens
9 Operational safety has a high priority here
10 Supervisors/managers rarely check that people here are working safely
11 My supervisor / manager encourages questions from workers about safety matters
12 People here are only interested in safety aspects of their own jobs, not other people's
13 The safety equipment (for example PPE, harnesses) here works well
14 There is timely feedback from the outcome of safety investigations
15 There is some risk taking at my workplace that I think is unnecessary
16 People here fully understand the risks associated with the work that they are responsible for
17 Safety decisions are made at the appropriate level
18 Most people in my workplace report safety-related occurrences
19 People here are not always confident that they have the experience to do the job
20 Managers are quick to act on safety concerns when we report them
21 I am regularly kept awake at night due to thinking about my job
22 People feel confident that they can question instructions when there may be safety issues
23 Safety will become less of a priority for Senior Leadership in the future
24 The Watch Chief would stop people working due to safety concerns even if it meant not getting the job done
25 Personal safety has a high priority here
26 If someone reports a safety concern here, I am confident it will be addressed
27 People here are kept informed about the outcomes of meetings which address safety issues
28 The Squadron Management is good at finding the right balance between addressing safety concerns and the requirement to achieve a task
29 My supervisor / manager encourages me and my team to learn from safety events
30 Where I work hazards are appropriately assessed and controlled
31 People here feel at risk when they are doing their jobs
32 In general, supervisors are sufficiently experienced to meet the required level of supervision
33 Everyone here is sufficiently trained to undertake their tasks safely
34 If I thought no one else would find out, I would not report a colleague's error
35 Good safety behaviour is positively recognised by the line management here
36 People here are clear about what their responsibilities for safety are
37 People here always work safely, even when they are not being supervised
38 Managers here would rather know about safety issues than not know
39 Where I work there is a Just Culture that ensures people are treated fairly
40 People here take pride in doing things safely
41 People here are sufficiently experienced for the jobs they are required to do
42 Supervisors sometimes sign off work without checking
43 People here are not comfortable reporting their own mistakes
44 Managers are open to safety concerns raised by employees
45 My workplace identifies hazards and assesses risk

46 Managers turn a blind eye to rule bending
47 The Squadron management here do a good job balancing operational requirements against safety
48 People regularly get distracted when doing safety critical jobs
49 Tools and equipment are maintained to a high standard in this organisation
50 People here take shortcuts when they think there is little or no risk involved
51 People here can easily identify the relevant safety procedure for their job
52 There are always supervisors available to give advice
53 Supervisors shield personnel from pressure
54 People here have a clear understanding of the safety procedures for their job
55 When there is pressure people will not compromise on what they see as safety critical issues
56 Some safety procedures are only there to protect management's back
57 Manning is appropriate to meet operational demands
58 Operational capability is usually seen as more important than safety
59 People make mistakes because they are trying to do too many jobs at once
60 Supervisors here sometimes encourage others to bend the rules or amend the procedure to achieve a task
61 The Senior Leadership in the FAA mean it when they say that safety is of the highest priority
62 If people see others breaking a rule they tend to turn a blind eye
63 There is too much paperwork involved with reporting safety concerns
64 If a genuine error is made (resulting in an accident or near miss), management will always be supportive
65 Most people are confident enough to speak up if they identify a safety issue
66 Line management looks out for us here
67 People here find it difficult to cope with pressure
68 There are enough people to do the job safely
69 I am confident my line management will act in the interests of our team in terms of safety
70 It is too bureaucratic to report all safety concerns
71 Safety rules / procedures are only there to protect against legal action
72 Command here places appropriate focus on safety
73 People sometimes turn a blind eye to less important safety procedures
74 Operational demands mean sometimes people have to take shortcuts
75 People here get frustrated by shortages of tools or equipment
76 If people followed all the safety rules they would not get the job done in time
77 People here are good at coping with pressure
78 There is poor communication about safety issues that affect me

Participant information sheet

Study title

Development of a Safety Culture questionnaire for use in the Royal Navy's Fleet Air Arm.

Invitation to take part

We would like to invite you to participate in this study being undertaken by the Institute of Naval Medicine (INM) in support of Royal Navy Flight Safety Centre (RNFSC) objectives. Before you decide whether you want to take part, it is important for you to understand why the research is being undertaken and what your participation will involve. Please take time to read the following information carefully. You must be a minimum age of 18 years old to participate in this study.

What is the purpose of the research?

The aim of the research is to develop a questionnaire, specific to the Fleet Air Arm, that can be used to investigate the attitudes and perceptions of personnel toward aspects of safety within the Fleet Air Arm. This will help to inform the RNFSC with regards to areas of concern or good safety culture and support the Safety Management System of the FAA. The aim of this is to support effective safety and risk management to ensure ongoing operational capability.

Who is doing this research?

This study is being undertaken by MOD personnel from the INM on behalf of the RNFSC.

Why have I been invited to take part?

You have been specifically invited to participate in this study as you are a member of the Fleet Air Arm.

Do I have to take part?

No, participation in the study is voluntary. Any responses will be confidential. There will be no negative impact on you, or your career, if you choose not to participate.

What will I be asked to do?

You will be given information about the study via Squadron communication channels at least 24h prior to consenting. If you have questions, the contact details of the Chief Investigator are at the end of this information sheet. You will also be given time to ask questions on the day. If you would like to participate in the study, you will be asked to read and sign a consent form to say that you have read and understood this information and consent to take part in this survey. After this, you will be invited to complete the questionnaire. The first part will ask you questions about aspects of where you are based, what aircraft you work on and what rank you are. These will not be used to identify you in any way, but so we can ensure we have a variety of people answering the questionnaires. The second part will ask you questions relating to safety in your workplace - please answer honestly. The survey should take approximately ten to fifteen minutes to complete. Although we are asking you questions about what aircraft type you work on and where you are based, these will not be used to identify you as all of the results will be grouped together.

A very small number of people will be asked to complete the survey twice, if this is the case we will provide you with another questionnaire and details of when to fill it in.

What is the device or procedure that is being tested?

The purpose is the development of a questionnaire to measure attitudes toward safety culture to help the RNFSC understand what people in the FAA think about safety and how it is managed in the FAA.

What are the benefits of taking part?

There are no direct benefits, however your participation will help to ensure that the resulting questionnaire will be specific and useful to the FAA for use as an indication of safety attitudes in the Fleet Air Arm. This will support the Safety Management of the FAA.

What are the possible disadvantages and risks of taking part?

There are no expected disadvantages or risks of taking part.

Can I withdraw from the research and what will happen if I don't want to carry on?

You may withdraw from the study at any time without giving a reason, the details of the Chief Investigator are included for contact if this is the case. Your data will be withdrawn from the study at your request and there will be no impact on your career.

Are there any expenses and payments which I will get?

No

Will my taking part or not taking part affect my Service career or medical care?

No, choosing not to take part will not disadvantage you in any way with regards to your career.

Whom do I contact if I have any questions or a complaint?

If you have any questions concerning this study, please do not hesitate to contact the Chief Investigator (details below).

For any complaints, please contact the named civilian Medical Officer who is independent of the study (details below).

What happens if I suffer any harm?

In the event of you suffering any adverse effects as a consequence of your participation in this study, you will be eligible to apply for compensation under the MOD’s ‘No Fault Compensation Scheme’.

Will my records be kept confidential?

Experimental records will at all times remain confidential and will be held for a minimum of 100 years in conditions appropriate for the storage of personal information. You have the right of access to your records at any time, and to ask for them to be destroyed.

Who is organising and funding the research?

This study has been tasked by the RNFSC and is being funded by the UK MOD. Part of this work will form the basis of a Doctoral thesis undertaken by the Chief Investigator at the University of Bath.

Who has reviewed the study?

This study has been reviewed and given favourable opinion by the Ministry of Defence Research Ethics Committee (MoDREC).

Further information and contact details.

Contact Details of Chief Investigator:
Mrs Anthea Ashford (Higher Scientific Officer)
Environmental Medicine and Science, Institute of Naval Medicine,
Crescent Road, Alverstoke, Hants. PO12 2DL
Telephone: [redacted]
Email:

Details of Independent Contact for complaints:
Dr Daniel Roiz de Sa (Civilian Medical Officer)
Environmental Medicine and Science, Institute of Naval Medicine,
Crescent Road, Alverstoke, Hants. PO12 2DL
Telephone: [redacted]
E-mail:

Compliance with the Declaration of Helsinki.

This study complies, and at all times will comply, with the Declaration of Helsinki[6] as adopted at the 64th WMA General Assembly at Fortaleza, Brazil in October 2013.

[6] World Medical Association Declaration of Helsinki [revised October 2013]. Recommendations Guiding Medical Doctors in Biomedical Research Involving Human Subjects. 64th WMA General Assembly, Fortaleza (Brazil).

Informed consent

Title of Study: Development of a Safety Culture questionnaire for use in the Royal Navy's Fleet Air Arm.

Ministry of Defence Research Ethics Committee Reference : 648/MODREC/15

- The nature, aims and risks of the research have been explained to me. I have read and understood the Information for Participants and understand what is expected of me. All my questions have been answered fully to my satisfaction.

- I understand that if I decide at any time during the research that I no longer wish to participate in this project, I can notify the researchers involved and be withdrawn from it immediately without having to give a reason. I also understand that I may be withdrawn from it at any time, and that in neither case will this be held against me in subsequent dealings with the Ministry of Defence.

- I consent to the processing of my personal information for the purposes of this research study. I understand that such information will be treated as strictly confidential and handled in accordance with the provisions of the Data Protection Act 1998.

- I agree to volunteer as a participant for the study described in the information sheet and give full consent.

- This consent is specific to the particular study described in the Information for Participants attached and shall not be taken to imply my consent to participate in any subsequent study or deviation from that detailed here.

- I understand that in the event of my sustaining injury, illness or death as a direct result of participating as a volunteer in Ministry of Defence research, I or my dependants may enter a claim with the Ministry of Defence for compensation under the provisions of the no-fault compensation scheme, details of which are attached.

Participant's Statement:

I ____

agree that the research project named above has been explained to me to my satisfaction and I agree to take part in the study. I have read both the notes written above and the Participant Information Sheet about the project, and understand what the research study involves.

Signed Date

Witness Name
Signature

Investigator's Statement:

I ____

confirm that I have carefully explained the nature, demands and any foreseeable risks (where applicable) of the proposed research to the Participant.
Signed Date

AUTHORISING SIGNATURES

The information supplied above is to the best of my knowledge and belief accurate. I clearly understand my obligations and the rights of research participants, particularly concerning recruitment of participants and obtaining valid consent.

Signature of Chief Investigator

…………………………………………………… Date

Name and contact details of Chief Investigator:

Mrs Anthea Ashford (Higher Scientific Officer)
Environmental Medicine and Science, Institute of Naval Medicine,
Crescent Road, Alverstoke, Hants. PO12 2DL
Telephone: Mil: 9380 68044; Civ: 02392 768044
Email: NAVYINM-EMSHF ERG1@mod.uk

Partial confirmatory factor analysis formulae

Root mean square error of approximation (RMSEA):

(Formula 1) $$\text{RMSEA} = \sqrt{\frac{\chi^2\text{implied}-df\text{implied}}{(N-1)*df\text{implied}}}$$

Normed Fit Index (NFI)

(Formula 2) $$\text{NFI}= \frac{(\chi2\text{Null}-\chi2\text{Implied})}{\chi2\text{Null}}$$

Tucker-Lewis Index (TLI)

(Formula 3) $$\text{TLI}= \frac{(\chi2\text{Null}/df\text{Null})-\chi2\text{Implied}/df\text{implied}}{(\chi2\text{Null}/df\text{Null})-1}$$

Comparative Fit Index (CFI)

(Formula 4) $$\text{CFI}= 1-\frac{(\chi^2\text{implied}-df\text{implied})}{(\chi2\text{Null}/df\text{Null})}$$

Where χ^2implied = goodness of fit χ^2 and χ^2Null= Bartlett's test χ^2

Results

Table 1.

*Skewness and kurtosis statistics, with items removed from the factor analysis shown in **bold***

Descriptive Statistics

	N	Skewness		Kurtosis	
	Statistic	Statistic	Std. Error	Statistic	Std. Error
1_People I work with think safety is very important	**450**	**-1.014**	**.115**	**1.966**	**.230**
2_More people are made available to do a job if needed for safety reasons	449	-.591	.115	-.029	.230
3_There is support from line management in safety critical situations	444	-.792	.116	1.354	.231
4_Managers here are willing to listen to staff when it comes to the best way to do something	449	-.702	.115	.348	.230
5_The Squadron Management encourages safe working practices	448	-.794	.115	1.273	.230
6_If people here saw an unsafe act they would report it	450	-.653	.115	.460	.230
7_Generally, teams work well together in this organisation	**449**	**-.779**	**.115**	**1.771**	**.230**
8_Taking a shortcut to get work done quickly is seen as acceptable, as long as nothing happens	449	-.476	.115	-.334	.230
9_Operational safety has a high priority here	449	-.621	.115	.504	.230
10_Supervisors/managers rarely check that people here are working safely	450	-.709	.115	.162	.230
11_My supervisor / manager encourages questions from workers about safety matters	450	-.356	.115	-.355	.230
12_People here are only interested in safety aspects of their own jobs, not other people's	449	-.349	.115	-.407	.230
13_The safety equipment (for example PPE, harnesses) here works well	447	-.748	.115	.371	.230
14_There is timely feedback from the outcome of safety investigations	446	-.290	.116	-.118	.231
15_There is some risk taking at my workplace that I think is unnecessary	450	-.463	.115	-.492	.230
16_People here fully understand the risks associated with the work that they are responsible for	**450**	**-1.015**	**.115**	**2.120**	**.230**

17_Safety decisions are made at the appropriate level	**450**	**-1.058**	**.115**	**2.080**	**.230**
18_Most people in my workplace report safety-related occurrences	450	-.693	.115	-.103	.230
19_People here are not always confident that they have the experience to do the job	450	-.066	.115	-.971	.230
20_Managers are quick to act on safety concerns when we report them	450	-.609	.115	.879	.230
21_I am regularly kept awake at night due to thinking about my job	449	-.664	.115	-.610	.230
22_People feel confident that they can question instructions when there may be safety issues	**450**	**-1.175**	**.115**	**1.816**	**.230**
23_Safety will become less of a priority for Senior Leadership in the future	448	-.665	.115	.814	.230
24_The Watch Chief would stop people working due to safety concerns even if it meant not getting the job done	444	-.688	.116	.141	.231
25_Personal safety has a high priority here	449	-.633	.115	.858	.230
26_If someone reports a safety concern here, I am confident it will be addressed	**448**	**-.805**	**.115**	**1.604**	**.230**
27_People here are kept informed about the outcomes of meetings which address safety issues	448	-.525	.115	-.369	.230
28_The Squadron Management is good at finding the right balance between addressing safety concerns and the requirement to achieve a task	447	-.606	.115	.248	.230
29_My supervisor / manager encourages me and my team to learn from safety events	449	-.791	.115	.994	.230
30_Where I work hazards are appropriately assessed and controlled	**447**	**-.809**	**.115**	**2.132**	**.230**
31_People here feel at risk when they are doing their jobs	450	-.665	.115	.549	.230
32_In general, supervisors are sufficiently experienced to meet the required level of supervision	450	-.999	.115	.698	.230
33_Everyone here is sufficiently trained to undertake their tasks safely	450	-.892	.115	.813	.230
34_If I thought no one else would find out, I would not report a colleague's error	448	-.590	.115	-.105	.230
35_Good safety behaviour is positively recognised by the line management here	450	-.556	.115	-.162	.230
36_People here are clear about what their responsibilities for safety are	**450**	**-.897**	**.115**	**2.109**	**.230**
37_People here always work safely, even when they are not being supervised	450	-.292	.115	-.614	.230

38_Managers here would rather know about safety issues than not know	**450**	**-1.026**	**.115**	**1.797**	**.230**
39_Where I work there is a Just Culture that ensures people are treated fairly	**450**	**-1.003**	**.115**	**1.360**	**.230**
40_People here take pride in doing things safely	450	-.520	.115	.273	.230
41_People here are sufficiently experienced for the jobs they are required to do	450	-.694	.115	-.165	.230
42_Supervisors sometimes sign off work without checking	437	-.166	.117	-.799	.233
43_People here are not comfortable reporting their own mistakes	450	-.102	.115	-.815	.230
44_Managers are open to safety concerns raised by employees	**449**	**-.814**	**.115**	**2.027**	**.230**
45_My workplace identifies hazards and assesses risk	**448**	**-.606**	**.115**	**2.149**	**.230**
46_Managers turn a blind eye to rule bending	449	-.603	.115	-.154	.230
47_The Squadron management here do a good job balancing operational requirements against safety	448	-.639	.115	.287	.230
48_People regularly get distracted when doing safety critical jobs	448	-.393	.115	-.676	.230
49_Tools and equipment are maintained to a high standard in this organisation	445	-.497	.116	-.588	.231
50_People here take shortcuts when they think there is little or no risk involved	450	-.146	.115	-.959	.230
51_People here can easily identify the relevant safety procedure for their job	**450**	**-1.177**	**.115**	**2.680**	**.230**
52_There are always supervisors available to give advice	450	-.712	.115	-.032	.230
53_Supervisors shield personnel from pressure	450	-.076	.115	-.549	.230
54_People here have a clear understanding of the safety procedures for their job	450	-.783	.115	1.943	.230
55_When there is pressure people will not compromise on what they see as safety critical issues	449	-.433	.115	-.296	.230
56_Some safety procedures are only there to protect management's back	449	-.257	.115	-.733	.230
57_Manning is appropriate to meet operational demands	449	.607	.115	-.779	.230
58_Operational capability is usually seen as more important than safety	450	-.067	.115	-.713	.230
59_People make mistakes because they are trying to do too many jobs at once	450	.539	.115	-.373	.230

60_Supervisors here sometimes encourage others to bend the rules or amend the procedure to achieve a task	450	-.502	.115	-.347	.230
61_The Senior Leadership in the FAA mean it when they say that safety is of the highest priority	450	-.606	.115	.188	.230
62_If people see others breaking a rule they tend to turn a blind eye	450	-.295	.115	-.507	.230
63_There is too much paperwork involved with reporting safety concerns	449	-.002	.115	-.689	.230
64_If a genuine error is made (resulting in an accident or near miss), management will always be supportive	450	-.522	.115	-.080	.230
65_Most people are confident enough to speak up if they identify a safety issue	**450**	**-1.010**	**.115**	**.661**	**.230**
66_Line management looks out for us here	449	-.797	.115	.659	.230
67_People here find it difficult to cope with pressure	448	-.408	.115	-.263	.230
68_There are enough people to do the job safely	450	.002	.115	-.981	.230
69_I am confident my line management will act in the interests of our team in terms of safety	**450**	**-1.003**	**.115**	**2.047**	**.230**
70_It is too bureaucratic to report all safety concerns	449	-.103	.115	-.663	.230
71_Safety rules / procedures are only there to protect against legal action	450	-.293	.115	-.710	.230
72_Command here places appropriate focus on safety	**449**	**-.769**	**.115**	**1.613**	**.230**
73_People sometimes turn a blind eye to less important safety procedures	**450**	**.058**	**.115**	**-1.093**	**.230**
74_Operational demands mean sometimes people have to take shortcuts	449	.205	.115	-.941	.230
75_People here get frustrated by shortages of tools or equipment	445	.687	.116	-.137	.231
76_If people followed all the safety rules they would not get the job done in time	450	-.071	.115	-.971	.230
77_People here are good at coping with pressure	449	-.645	.115	.100	.230
78_There is poor communication about safety issues that affect me	448	-.543	.115	.198	.230
Valid N (listwise)	402				

Table 2.

PCA step 1, total variance explained

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	18.528	30.879	30.879	18.528	30.879	30.879	6.520	10.867	10.867
2	2.594	4.324	35.203	2.594	4.324	35.203	5.858	9.763	20.630
3	2.343	3.906	39.109	2.343	3.906	39.109	3.852	6.419	27.049
4	1.966	3.276	42.385	1.966	3.276	42.385	2.861	4.769	31.817
5	1.623	2.705	45.090	1.623	2.705	45.090	2.703	4.504	36.322
6	1.447	2.412	47.502	1.447	2.412	47.502	2.699	4.499	40.821
7	1.327	2.211	49.713	1.327	2.211	49.713	2.667	4.445	45.265
8	1.219	2.031	51.744	1.219	2.031	51.744	2.395	3.991	49.257
9	1.163	1.938	53.682	1.163	1.938	53.682	1.929	3.214	52.471
10	1.102	1.837	55.519	1.102	1.837	55.519	1.737	2.895	55.366
11	1.090	1.816	57.335	1.090	1.816	57.335	1.181	1.969	57.335
12	.981	1.635	58.970						
13	.928	1.546	60.516						
14	.907	1.511	62.028						
15	.881	1.469	63.496						
16	.827	1.379	64.876						
17	.815	1.359	66.235						
18	.804	1.340	67.574						
19	.784	1.307	68.882						
20	.764	1.274	70.155						
21	.741	1.234	71.390						

22	.709	1.182	72.571						
23	.703	1.171	73.742						
24	.688	1.147	74.890						
25	.673	1.122	76.012						
26	.657	1.096	77.108						
27	.638	1.063	78.171						
28	.634	1.057	79.228						
29	.604	1.007	80.235						
30	.588	.980	81.215						
31	.565	.941	82.156						
32	.555	.925	83.081						
33	.541	.901	83.982						
34	.532	.887	84.868						
35	.513	.855	85.723						
36	.508	.847	86.571						
37	.473	.788	87.359						
38	.466	.776	88.135						
39	.450	.750	88.885						
40	.427	.712	89.596						
41	.420	.701	90.297						
42	.406	.677	90.974						
43	.390	.650	91.624						
44	.380	.633	92.257						
45	.376	.627	92.884						
46	.370	.617	93.501						
47	.360	.600	94.100						
48	.352	.586	94.686						
49	.332	.554	95.240						
50	.323	.538	95.779						
51	.307	.512	96.290						
52	.303	.504	96.795						
53	.281	.468	97.263						
54	.269	.449	97.712						
55	.260	.434	98.146						

56	.249	.415	98.561						
57	.230	.383	98.944						
58	.224	.373	99.317						
59	.216	.360	99.677						
60	.194	.323	100.000						

Extraction Method: Principal Component Analysis.

Table 3.

PCA step 1, Component matrix

Component Matrix[a]

	Component										
	1	2	3	4	5	6	7	8	9	10	11
46_Managers turn a blind eye to rule bending	.701										
62_If people see others breaking a rule they tend to turn a blind eye	.683										
28_The Squadron Management is good at finding the right balance between addressing safety concerns and the requirement to achieve a task	.682										
4_Managers here are willing to listen to staff when it comes to the best way to do something	.674										
50_People here take shortcuts when they think there is little or no risk involved	.673										
47_The Squadron management here do a good job balancing operational requirements against safety	.663										
25_Personal safety has a high priority here	.660										
66_Line management looks out for us here	.658										
29_My supervisor / manager encourages me and my team to learn from safety events	.655										
40_People here take pride in doing things safely	.650										
37_People here always work safely, even when they are not being supervised	.647										
76_If people followed all the safety rules they would not get the job done in time	.645										

60_Supervisors here sometimes encourage others to bend the rules or amend the procedure to achieve a task	.631										
3_There is support from line management in safety critical situations	.627										
43_People here are not comfortable reporting their own mistakes	.614										
41_People here are sufficiently experienced for the jobs they are required to do	.613	.443									
27_People here are kept informed about the outcomes of meetings which address safety issues	.610										
77_People here are good at coping with pressure	.597										
74_Operational demands mean sometimes people have to take shortcuts	.589		.408								
67_People here find it difficult to cope with pressure	.587					-.419					
54_People here have a clear understanding of the safety procedures for their job	.584										
78_There is poor communication about safety issues that affect me	.580										
48_People regularly get distracted when doing safety critical jobs	.577										
33_Everyone here is sufficiently trained to undertake their tasks safely	.571	.420									
35_Good safety behaviour is positively recognised by the line management here	.570										
58_Operational capability is usually seen as more important than safety	.568										
20_Managers are quick to act on safety concerns when we report them	.568										
42_Supervisors sometimes sign off work without checking	.561										

11_My supervisor / manager encourages questions from workers about safety matters	.560										
18_Most people in my workplace report safety-related occurrences	.560										
8_Taking a shortcut to get work done quickly is seen as acceptable, as long as nothing happens	.552										
19_People here are not always confident that they have the experience to do the job	.549										
55_When there is pressure people will not compromise on what they see as safety critical issues	.544										
10_Supervisors/managers rarely check that people here are working safely	.531										
52_There are always supervisors available to give advice	.523										
32_In general, supervisors are sufficiently experienced to meet the required level of supervision	.523	.478									
34_If I thought no one else would find out, I would not report a colleague's error	.522										
24_The Watch Chief would stop people working due to safety concerns even if it meant not getting the job done	.521										
71_Safety rules / procedures are only there to protect against legal action	.521										
70_It is too bureaucratic to report all safety concerns	.520										
15_There is some risk taking at my workplace that I think is unnecessary	.518										
9_Operational safety has a high priority here	.518										
56_Some safety procedures are only there to protect management's back	.517										

64_If a genuine error is made (resulting in an accident or near miss), management will always be supportive	.515										
6_If people here saw an unsafe act they would report it	.513										
5_The Squadron Management encourages safe working practices	.512		-.408								
59_People make mistakes because they are trying to do too many jobs at once	.509										
12_People here are only interested in safety aspects of their own jobs, not other people's	.508										
68_There are enough people to do the job safely	.507										
2_More people are made available to do a job if needed for safety reasons	.489										
61_The Senior Leadership in the FAA mean it when they say that safety is of the highest priority	.485										
53_Supervisors shield personnel from pressure	.468										
49_Tools and equipment are maintained to a high standard in this organisation	.449										
23_Safety will become less of a priority for Senior Leadership in the future	.434										
14_There is timely feedback from the outcome of safety investigations											
75_People here get frustrated by shortages of tools or equipment											
31_People here feel at risk when they are doing their jobs											
57_Manning is appropriate to meet operational demands		.416									
63_There is too much paperwork involved with reporting safety concerns					.406						
13_The safety equipment (for example PPE, harnesses) here works well							.589				

Extraction Method: Principal Component Analysis.

a. 11 components extracted.

Table 4.

PCA model 1, rotated component matrix

Rotated Component Matrix[a]

	Component										
	1	2	3	4	5	6	7	8	9	10	11
29_My supervisor / manager encourages me and my team to learn from safety events	.640										
20_Managers are quick to act on safety concerns when we report them	.603										
35_Good safety behaviour is positively recognised by the line management here	.595										
64_If a genuine error is made (resulting in an accident or near miss), management will always be supportive	.591										
66_Line management looks out for us here	.580										
4_Managers here are willing to listen to staff when it comes to the best way to do something	.566										
5_The Squadron Management encourages safe working practices	.555										
27_People here are kept informed about the outcomes of meetings which address safety issues	.550										
28_The Squadron Management is good at finding the right balance between addressing safety concerns and the requirement to achieve a task	.547										
78_There is poor communication about safety issues that affect me	.540										
11_My supervisor / manager encourages questions from workers about safety matters	.515										
25_Personal safety has a high priority here	.479						.451				

47_The Squadron management here do a good job balancing operational requirements against safety	.462										
24_The Watch Chief would stop people working due to safety concerns even if it meant not getting the job done	.416										-.413
61_The Senior Leadership in the FAA mean it when they say that safety is of the highest priority											
50_People here take shortcuts when they think there is little or no risk involved		.691									
8_Taking a shortcut to get work done quickly is seen as acceptable, as long as nothing happens		.680									
46_Managers turn a blind eye to rule bending		.676									
62_If people see others breaking a rule they tend to turn a blind eye		.637									
42_Supervisors sometimes sign off work without checking		.620									
60_Supervisors here sometimes encourage others to bend the rules or amend the procedure to achieve a task		.574									
74_Operational demands mean sometimes people have to take shortcuts		.558									
43_People here are not comfortable reporting their own mistakes		.455									
76_If people followed all the safety rules they would not get the job done in time		.415				.415					
40_People here take pride in doing things safely											
23_Safety will become less of a priority for Senior Leadership in the future											
32_In general, supervisors are sufficiently experienced to meet the required level of supervision			.790								

33_Everyone here is sufficiently trained to undertake their tasks safely			.751								
41_People here are sufficiently experienced for the jobs they are required to do			.727								
52_There are always supervisors available to give advice			.516								
37_People here always work safely, even when they are not being supervised			.425								
54_People here have a clear understanding of the safety procedures for their job											
6_If people here saw an unsafe act they would report it				.689							
18_Most people in my workplace report safety-related occurrences				.675							
34_If I thought no one else would find out, I would not report a colleague's error		.414		.525							
67_People here find it difficult to cope with pressure					.694						
77_People here are good at coping with pressure					.565						
19_People here are not always confident that they have the experience to do the job			.468		.495						
58_Operational capability is usually seen as more important than safety					.453						
48_People regularly get distracted when doing safety critical jobs		.410			.418						
63_There is too much paperwork involved with reporting safety concerns						.737					
70_It is too bureaucratic to report all safety concerns						.713					
71_Safety rules / procedures are only there to protect against legal action						.626					
56_Some safety procedures are only there to protect management's back		.458				.485					

2_More people are made available to do a job if needed for safety reasons							.620				
3_There is support from line management in safety critical situations							.472				
9_Operational safety has a high priority here							.471				
31_People here feel at risk when they are doing their jobs							.439				
15_There is some risk taking at my workplace that I think is unnecessary							.431				
57_Manning is appropriate to meet operational demands								.753			
68_There are enough people to do the job safely								.698			
59_People make mistakes because they are trying to do too many jobs at once								.437			
53_Supervisors shield personnel from pressure									.594		
55_When there is pressure people will not compromise on what they see as safety critical issues											
13_The safety equipment (for example PPE, harnesses) here works well										.743	
49_Tools and equipment are maintained to a high standard in this organisation										.512	
14_There is timely feedback from the outcome of safety investigations										.471	
75_People here get frustrated by shortages of tools or equipment											
12_People here are only interested in safety aspects of their own jobs, not other people’s											.469
10_Supervisors/managers rarely check that people here are working safely											

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 19 iterations.

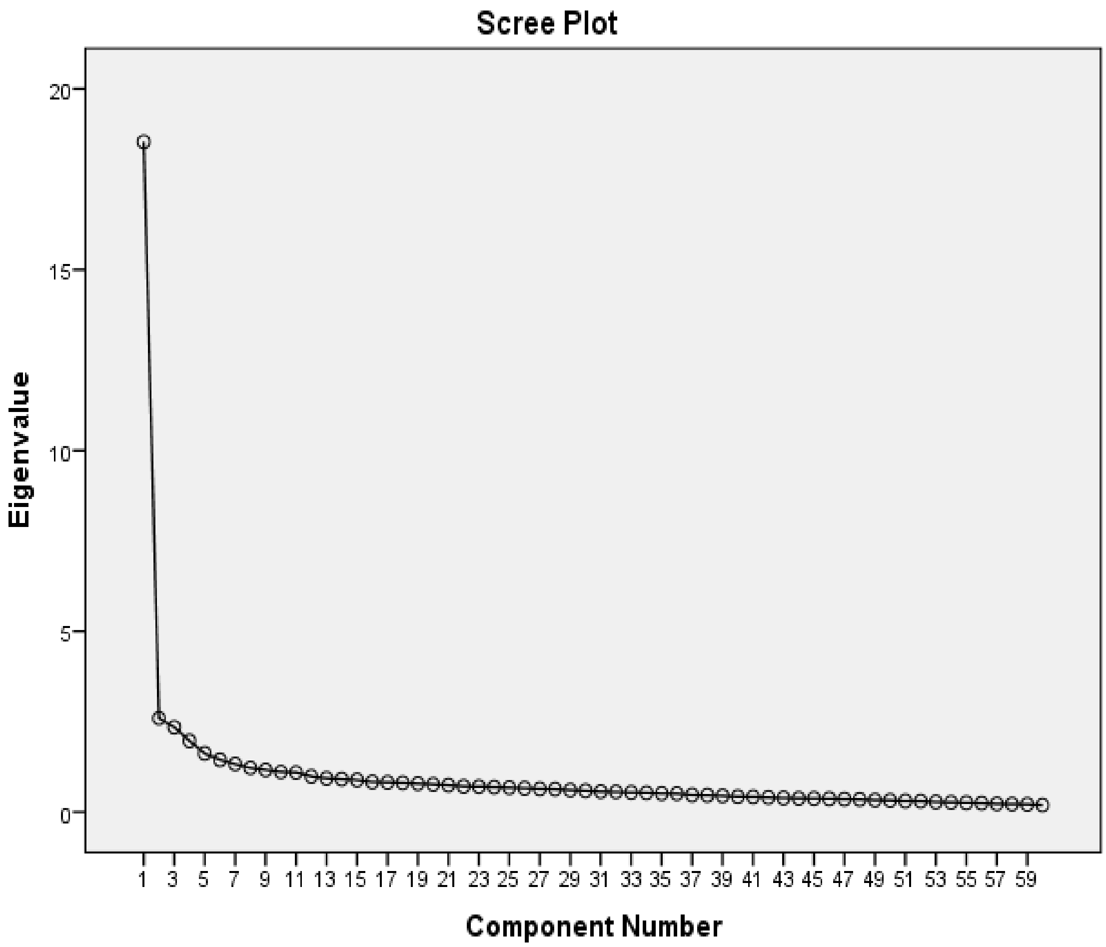


Figure 1. Scree plot from PCA

Table 5.

PCA step 2- Direct oblimin test component matrix

Component Matrix[a]

	Component										
	1	2	3	4	5	6	7	8	9	10	11
46_Managers turn a blind eye to rule bending	.701										
62_If people see others breaking a rule they tend to turn a blind eye	.683										
28_The Squadron Management is good at finding the right balance between addressing safety concerns and the requirement to achieve a task	.682										
4_Managers here are willing to listen to staff when it comes to the best way to do something	.674										
50_People here take shortcuts when they think there is little or no risk involved	.673										
47_The Squadron management here do a good job balancing operational requirements against safety	.663										
25_Personal safety has a high priority here	.660										
66_Line management looks out for us here	.658										
29_My supervisor / manager encourages me and my team to learn from safety events	.655										
40_People here take pride in doing things safely	.650										
37_People here always work safely, even when they are not being supervised	.647										
76_If people followed all the safety rules they would not get the job done in time	.645										

60_Supervisors here sometimes encourage others to bend the rules or amend the procedure to achieve a task	.631										
3_There is support from line management in safety critical situations	.627										
43_People here are not comfortable reporting their own mistakes	.614										
41_People here are sufficiently experienced for the jobs they are required to do	.613	.443									
27_People here are kept informed about the outcomes of meetings which address safety issues	.610										
77_People here are good at coping with pressure	.597										
74_Operational demands mean sometimes people have to take shortcuts	.589		.408								
67_People here find it difficult to cope with pressure	.587					-.419					
54_People here have a clear understanding of the safety procedures for their job	.584										
78_There is poor communication about safety issues that affect me	.580										
48_People regularly get distracted when doing safety critical jobs	.577										
33_Everyone here is sufficiently trained to undertake their tasks safely	.571	.420									
35_Good safety behaviour is positively recognised by the line management here	.570										
58_Operational capability is usually seen as more important than safety	.568										
20_Managers are quick to act on safety concerns when we report them	.568										
42_Supervisors sometimes sign off work without checking	.561										

11_My supervisor / manager encourages questions from workers about safety matters	.560										
18_Most people in my workplace report safety-related occurrences	.560										
8_Taking a shortcut to get work done quickly is seen as acceptable, as long as nothing happens	.552										
19_People here are not always confident that they have the experience to do the job	.549										
55_When there is pressure people will not compromise on what they see as safety critical issues	.544										
10_Supervisors/managers rarely check that people here are working safely	.531										
52_There are always supervisors available to give advice	.523										
32_In general, supervisors are sufficiently experienced to meet the required level of supervision	.523	.478									
34_If I thought no one else would find out, I would not report a colleague's error	.522										
24_The Watch Chief would stop people working due to safety concerns even if it meant not getting the job done	.521										
71_Safety rules / procedures are only there to protect against legal action	.521										
70_It is too bureaucratic to report all safety concerns	.520										
15_There is some risk taking at my workplace that I think is unnecessary	.518										
9_Operational safety has a high priority here	.518										
56_Some safety procedures are only there to protect management's back	.517										
64_If a genuine error is made (resulting in an accident or near miss), management will always be supportive	.515										

6_If people here saw an unsafe act they would report it	.513										
5_The Squadron Management encourages safe working practices	.512		-.408								
59_People make mistakes because they are trying to do too many jobs at once	.509										
12_People here are only interested in safety aspects of their own jobs, not other people's	.508										
68_There are enough people to do the job safely	.507										
2_More people are made available to do a job if needed for safety reasons	.489										
61_The Senior Leadership in the FAA mean it when they say that safety is of the highest priority	.485										
53_Supervisors shield personnel from pressure	.468										
49_Tools and equipment are maintained to a high standard in this organisation	.449										
23_Safety will become less of a priority for Senior Leadership in the future	.434										
14_There is timely feedback from the outcome of safety investigations											
75_People here get frustrated by shortages of tools or equipment											
31_People here feel at risk when they are doing their jobs											
57_Manning is appropriate to meet operational demands		.416									
63_There is too much paperwork involved with reporting safety concerns					.406						
13_The safety equipment (for example PPE, harnesses) here works well							.589				

Extraction Method: Principal Component Analysis.

a. 11 components extracted.

Table 6.

PCA Final 6 factor solution, total variance explained

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	13.969	34.070	34.070	13.969	34.070	34.070	5.935	14.475	14.475
2	2.289	5.582	39.652	2.289	5.582	39.652	5.326	12.990	27.465
3	2.131	5.197	44.849	2.131	5.197	44.849	3.599	8.778	36.243
4	1.700	4.146	48.994	1.700	4.146	48.994	2.764	6.741	42.984
5	1.367	3.334	52.328	1.367	3.334	52.328	2.593	6.325	49.308
6	1.162	2.834	55.162	1.162	2.834	55.162	2.400	5.854	55.162
7	.991	2.417	57.579						
8	.926	2.258	59.837						
9	.901	2.198	62.034						
10	.858	2.093	64.127						
11	.779	1.900	66.028						
12	.716	1.746	67.773						
13	.709	1.728	69.501						
14	.689	1.680	71.181						
15	.682	1.664	72.844						
16	.664	1.620	74.464						
17	.650	1.585	76.050						
18	.612	1.492	77.541						
19	.603	1.470	79.011						
20	.569	1.388	80.399						
21	.554	1.352	81.750						
22	.528	1.289	83.039						
23	.514	1.254	84.293						
24	.491	1.198	85.490						
25	.478	1.166	86.656						
26	.448	1.092	87.748						
27	.442	1.079	88.827						

28	.419	1.022	89.849						
29	.405	.988	90.837						
30	.393	.958	91.796						
31	.386	.941	92.737						
32	.382	.931	93.668						
33	.348	.848	94.515						
34	.328	.800	95.315						
35	.317	.774	96.090						
36	.294	.717	96.807						
37	.293	.714	97.521						
38	.275	.671	98.192						
39	.266	.650	98.842						
40	.254	.619	99.461						
41	.221	.539	100.000						

Extraction Method: Principal Component Analysis.

Table 7.

PCA Final 6 factor solution, rotated component matrix

Rotated Component Matrix[a]

	Component					
	1	2	3	4	5	6
5_The Squadron Management encourages safe working practices	.660					
4_Managers here are willing to listen to staff when it comes to the best way to do something	.656					
66_Line management looks out for us here	.647					
20_Managers are quick to act on safety concerns when we report them	.639					
28_The Squadron Management is good at finding the right balance between addressing safety concerns and the requirement to achieve a task	.607					
78_There is poor communication about safety issues that affect me	.606					
29_My supervisor / manager encourages me and my team to learn from safety events	.596					
64_If a genuine error is made (resulting in an accident or near miss), management will always be supportive	.593					
25_Personal safety has a high priority here	.548					
47_The Squadron management here do a good job balancing operational requirements against safety	.541					
35_Good safety behaviour is positively recognised by the line management here	.541					
3_There is support from line management in safety critical situations	.485					
27_People here are kept informed about the outcomes of meetings which address safety issues	.462					
11_My supervisor / manager encourages questions from workers about safety matters	.461					
50_People here take shortcuts when they think there is little or no risk involved		.710				
8_Taking a shortcut to get work done quickly is seen as acceptable, as long as nothing happens		.659				
46_Managers turn a blind eye to rule bending		.651				

74_Operational demands mean sometimes people have to take shortcuts		.642				
60_Supervisors here sometimes encourage others to bend the rules or amend the procedure to achieve a task		.641				
62_If people see others breaking a rule they tend to turn a blind eye		.615		.425		
42_Supervisors sometimes sign off work without checking		.573				
48_People regularly get distracted when doing safety critical jobs		.526				
43_People here are not comfortable reporting their own mistakes		.513				
76_If people followed all the safety rules they would not get the job done in time		.484				.462
59_People make mistakes because they are trying to do too many jobs at once		.434			.432	
32_In general, supervisors are sufficiently experienced to meet the required level of supervision			.808			
41_People here are sufficiently experienced for the jobs they are required to do			.769			
33_Everyone here is sufficiently trained to undertake their tasks safely			.740			
52_There are always supervisors available to give advice			.576			
19_People here are not always confident that they have the experience to do the job			.532			
37_People here always work safely, even when they are not being supervised			.439	.420		
6_If people here saw an unsafe act they would report it				.707		
18_Most people in my workplace report safety-related occurrences				.695		
34_If I thought no one else would find out, I would not report a colleague's error				.551		
68_There are enough people to do the job safely					.715	
2_More people are made available to do a job if needed for safety reasons					.670	
57_Manning is appropriate to meet operational demands					.668	
63_There is too much paperwork involved with reporting safety concerns						.777

70_It is too bureaucratic to report all safety concerns						.712
71_Safety rules / procedures are only there to protect against legal action						.611
56_Some safety procedures are only there to protect management's back		.453				.473

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 8 iterations.

Table 8.

Goodness of fit test for PCFA

Goodness-of-fit Test

Chi-Square	df	Sig.
1446.946	1165	.000

Appendix E-Study 4

Method

Table 1

Six components from PCA, containing 41 constituent items and internal reliability (Cronbach alpha α) of each component

Component 1 - Management & organisational learning (α = 0.908)	
Mgt1	Managers are willing to listen to staff when it comes to the best way to do something
Mgt2	The Squadron Management encourages safe working practices
Mgt3	Line management looks out for us here
Mgt4	Managers are quick to act on safety concerns when we report them
Mgt5	The Squadron Management is good at finding the right balance between addressing safety concerns and the requirement to achieve a task
Mgt6	There is poor communication about safety issues that may affect me
Mgt7	My supervisor / manager encourages me and my team to learn from safety events
Mgt8	If a genuine error is made (resulting in an accident or near miss), management will always be supportive
Mgt9	Personal safety has a high priority here
Mgt10	The squadron management here do a good job balancing operational requirements against safety
Mgt11	Good safety behaviour is positively recognised by the line management here
Mgt12	There is support from Management in safety critical situations
Mgt13	People here are kept informed about the outcomes of meetings which address safety issues
Mgt14	My supervisor/manager encourages questions from workers about safety matters
Component 2- Normative behaviour (α = 0.898)	
Norm1	People here take shortcuts when they think there is little or no risk involved
Norm2	Taking a short cut to get work done quickly is seen as acceptable, as long as nothing happens
Norm3	Managers turn a blind eye to rule bending
Norm4	Operational demands mean sometimes people have to take shortcuts

Norm5	Supervisors here sometimes encourage others to bend the rules or amend the procedure to achieve a task
Norm6	Supervisors sometimes sign off without checking
Norm7	People regularly get distracted when doing safety critical jobs
Norm8	People here are not comfortable reporting their own mistakes
Component 3- Training & Experience (α =0.841)	
Tr1	In general, supervisors are sufficiently experienced to meet the required level of supervision
Tr2	People are sufficiently experienced for the jobs they are required to do
Tr3	Everyone here is sufficiently trained to undertake their tasks safely
Tr4	There are always supervisors available to give advice
Tr5	People here are not always confident that they have the experience to do the job
Tr6	People here always work safely, even when they are not being supervised
Component 4- Reporting (α =0.804)	
Rep1	If people here saw an unsafe act they would report it
Rep2	Most people in my workplace report safety related occurrences
Rep3	If I thought no one would know, I would not report a colleague's error
Rep4	If people see others breaking a rule they tend to turn a blind eye
Component 5 - Human resources (α =0.710)	
Man1	There are enough people to do the job safely
Man2	More people are made available to do a job if needed for safety reasons
Man3	Manning is appropriate to meet operational demands
Man4	People make mistakes because they are trying to do too many jobs at once
Component 6- Process/bureaucracy (α =0.786)	
Pro1	There is too much paperwork involved with reporting safety concerns
Pro2	It is too bureaucratic to report all safety concerns
Pro3	Safety rules / procedures are only there to protect against legal action
Pro4	If people followed all the safety rules they would not get the job done in time
Pro5	Some procedures are only there to protect management's back

Results

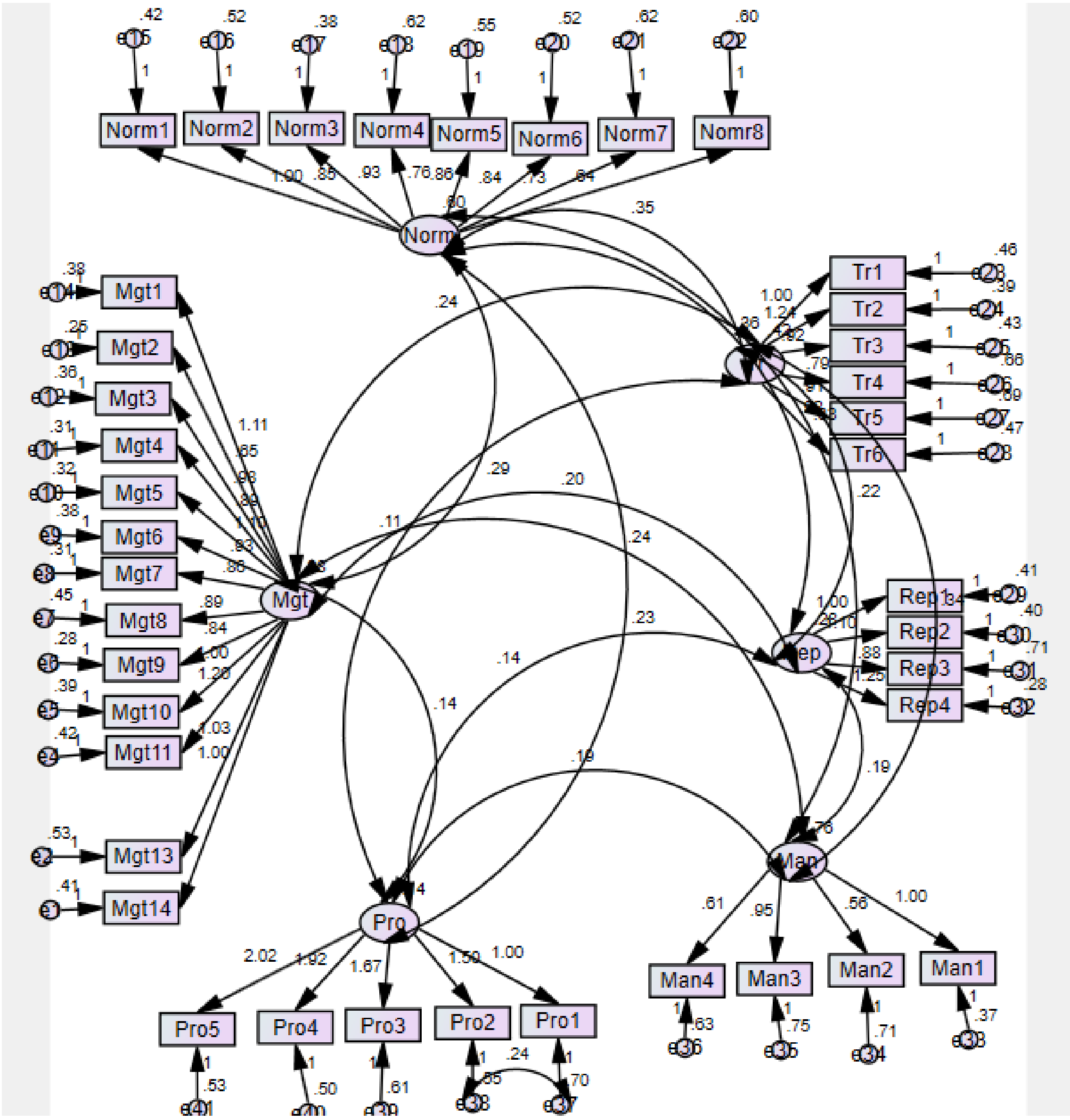


Figure 1. Model1 - Hypothesised model, 6 components

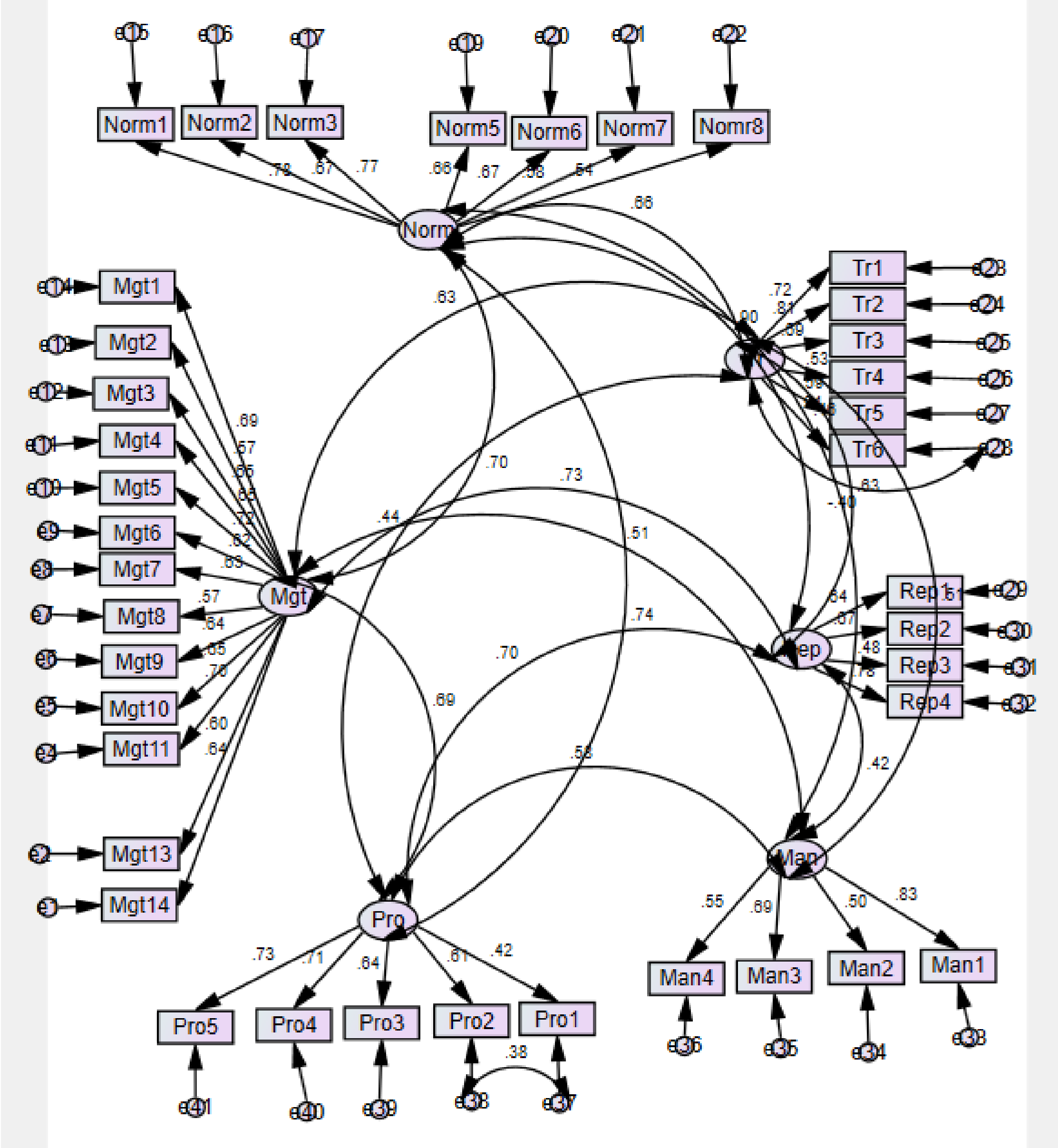


Figure 2. Model 2-Respecified model, 6 components

Table 2.

Tests for normality on five safety climate proto-scales

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Managementorglearn	.082	454	.000	.979	454	.000
Normativebehaviour	.101	454	.000	.980	454	.000
Trainexpsup	.119	454	.000	.966	454	.000
Reporting	.113	454	.000	.971	454	.000
Processburea	.070	454	.000	.988	454	.001

a. Lilliefors Significance Correction